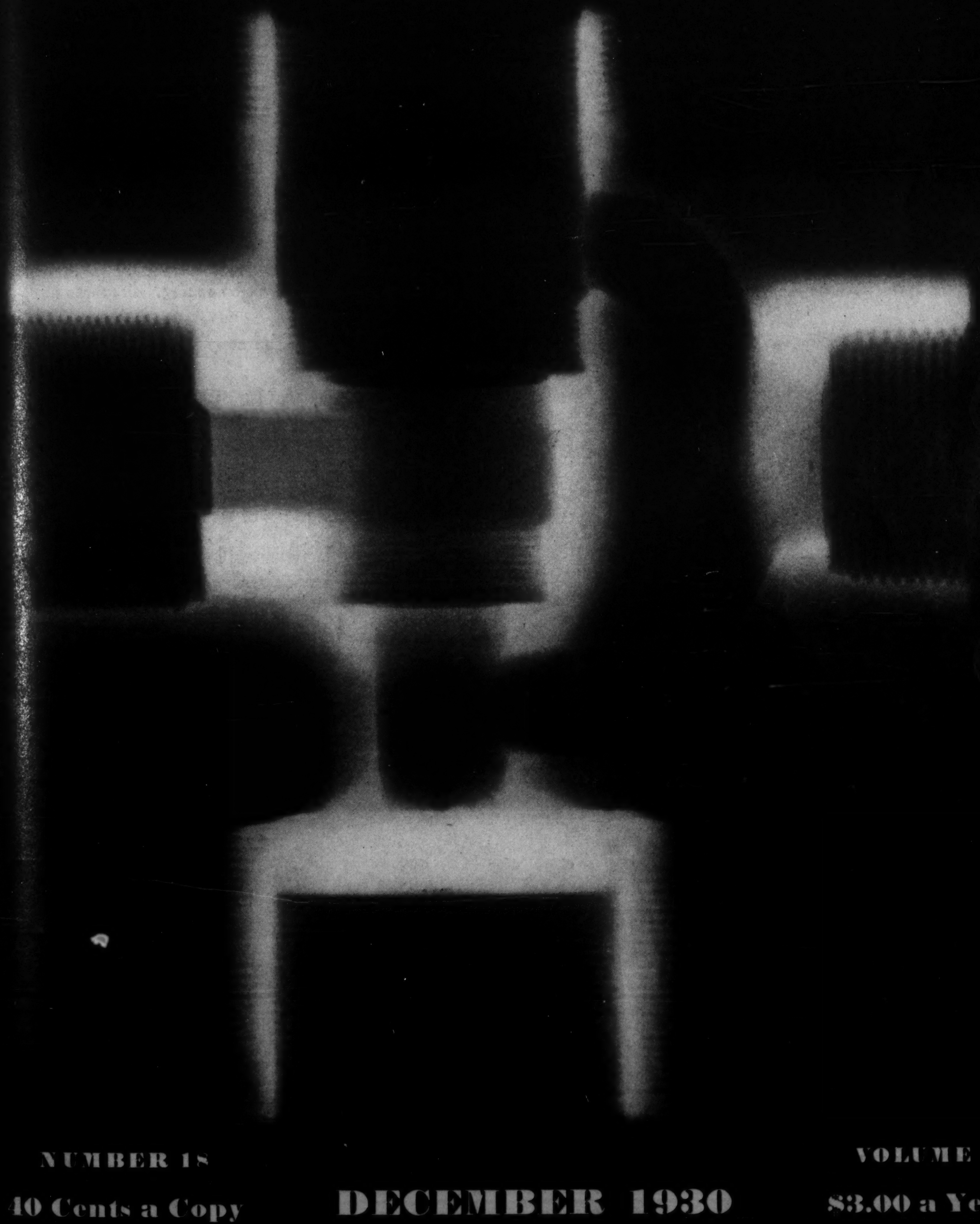
METALS & ALLOYS

Registered in the U.S. Patent Office

Devoted to Engineering Metallurgy



NUMBER 18
40 Cents a Copy

DECEMBER 1930

VOLUME 1
$3.00 a Year

The Amsler Machine

TYPE No. 5 K P 184

. . . . for Standard Brinell and Diamond Pyramid Hardness Tests . . . .

ADJUSTABLE to 7 full ranges of sensitiveness: 0 to 50, 100, 300, 500, 1000, 3000, 5000 kg.

Constructed for hand or electric motor drive, with accurately adjustable testing speed, with load measurement by pendulum manometer ("primary standard," self-balancing, direct-reading, invariable).

The following attachments can be supplied for use with this hardness testing machine:

- Transverse testing arrangement for cast iron bars, with direct-reading deflection indicator;
- Arrangement for cold-bending tests;
- Arrangement for tension tests of wires and sheets;
- Arrangement for shearing tests of wires;
- Arrangement for sheet metal cupping (ductility) tests;
- Arrangement for compression tests of materials, of coiled springs, etc.

Since this machine possesses a very accurate, self-balancing weighing system, the tests are not limited to definite "steps," as in most other hardness testing machines, but measurements of loads can be made, with high accuracy, in any part of the scale. For each of the 7 ranges, the scale is available in its entirety. If the machine is set, for instance, for maximum 50 kg loads, tests can be made very accurately at 10 kg, 15 kg, or any other pressures desired between 0 and 50 kg.

. . . . . WRITE FOR LEAFLET No. 102,
CONTAINING FULL INFORMATION

HERMAN A. HOLZ

TESTING ENGINEER

167 EAST 33rd STREET
NEW YORK

COMPLETE LINE OF MACHINES AND INSTRUMENTS OF HIGH QUALITY FOR THE TESTING OF METALS AND METAL PRODUCTS - - - - - - -

"FOR EVERY TEST—THE BEST"

METALS & ALLOYS

Devoted to Engineering Metallurgy

H. W. Gillett, Editorial Director

Editorial Advisory Board

H. A. ANDERSON
Western Electric Company
W. H. BASSETT
American Brass Company
A. L. BOEGEHOLD
General Motors Corporation
P. H. BRACE
Westinghouse Electric and Manufacturing Company
H. J. FRENCH
International Nickel Company
S. L. HOYT
General Electric Company
J. B. JOHNSON
Army Air Corps
JOHN JOHNSTON
U. S. Steel Corporation
JAMES T. MACKENZIE
American Cast Iron Pipe Company
JOHN A. MATHEWS
Crucible Steel Company of America
W. B. PRICE
Scovill Manufacturing Company
H. A. SCHWARTZ
National Malleable and Steel Castings Company
F. N. SPELLER
National Tube Company
L. W. SPRING
Crane Co.
JEROME STRAUSS
Vanadium Corporation of America

FRANCIS M. TURNER, Managing Editor
RICHARD RIMBACH, Associate Editor

Published Monthly by The Chemical Catalog Company, Inc.

Publication Office: 20th and Northampton Sts., Easton, Pa.

Editorial and Advertising Office: 419 Fourth Ave., New York.

Francis M. Turner, Pres.
H. Burton Lowe, Vice-Pres.
R. W. Reinhold, Secy.-Treas.

Annual Subscription: U. S., Possessions, Mexico and Cuba, $3.00; Canada, $3.50; Other Countries, $4.00; Single copies, 40c.

All communications relating to subscriptions or back issues should be addressed to METALS & ALLOYS, 419 Fourth Avenue, New York.

Copyright, 1930, by The Chemical Catalog Company, Inc. All rights reserved.

Entered as second-class matter July 23, 1929, at the post office at Easton, Pa., under the act of March 3, 1879.

CONTENTS

DECEMBER, 1930

Radiograph of Machined, Bronze Valve Casting . . . . Cover

Metallurgy and the Power Industry . . . 868
J. B. Romer

Do You Need Better Alloys for High Temperature Service? 870

The Technique of Radiography by Gamma Rays 872
C. S. Barrett, R. A. Gezelius and R. F. Mehl

Present Aspects of Materials for High Temperature Service from the Creep Design Standpoint 880
J. J. Kanter and L. W. Spring

Fundamental and Applied Research on the Physical Chemistry of Steel-Making . . 883
C. H. Herty, Jr.

Editorials 865-866
Readers' Comments 867
The Influence of a Small Addition of Copper on the Corrosion Resistance of Structural Steel (Extended Abstract) 890
Corrosion and Metal Protection in Boiler Practice (Translation) 895
Current Metallurgical Literature Abstracts 897
Book Reviews 917
Patent Department 919
Manufacturers' Literature Reviews 5

Correction 866
Richard G. Moldenke 867
Herbert H. Dow 879
Calendar of Meetings 889
Personals 916
News Notes 871:879:916:924

HORSE HEAD UNIFORM QUALITY ZINC

FOR DIE CASTINGS

New cases for a leading alarm clock, die cast from an alloy of Horse Head Zinc. Butler Silver Finish.

Combining ACCURACY of dimension, FLEXIBILITY of design, BEAUTY of finish, SPEED of production.

THE NEW JERSEY ZINC COMPANY
160 FRONT STREET, NEW YORK CITY

Zinc Metal and Alloys ▪ Rolled Zinc ▪ Zinc Pigments ▪ Sulphuric Acid ▪ Spiegeleisen

Editorial Comment

Metals and Alloys for Use at High Temperatures and Pressures

The most embarrassing question the metallurgist can be asked is how a given alloy will stand up over a long period of time in service involving repeated stress, wear, corrosion or high temperature.

The engineer is asking these questions in louder and louder tones, because he has to have the answers in order to design apparatus and machine parts that are safe, in the first place, and not too heavy nor expensive, in the second. If the engineer is too conservative, he builds an apparatus that is safe, but less efficient than it might be. If he is too rash, his apparatus may fail. The failures seldom occur at once, but after a period of months or years. We can't wait for observations of service results to bring the information. Hence, to get the sort of data the engineer needs, the metallurgist has first to work out methods of accelerated testing that are reliable. Then he has to get them generally accepted and standardized, so that all those who make tests and get data, will make their tests in such fashion that the results can be compared. Next in order, is the collection of data on existing alloys. The study of such data gives an inkling of how other improved alloys designed to meet a particular condition, may be produced.

We are running a series of articles aimed to bring out just how far the metallurgist can answer the engineer's question in regard to these various types of severe service. As is pointed out in that series, we are really beginning to know something about the behavior of metals under repeated stress, though there are still many baffling questions to be solved.

We probably know less about the mechanism of wear or of how to test the wear resistance of a metal than we do about other kinds of severe service. But fortunately it is usually possible to tell when a thing is wearing out in time to replace it before it actually fails. Wearing parts can usually be inspected, or the progress of wear detected—often by the ear alone.

The progress of corrosion is less readily detected, many corroding parts being inaccessible, and the surface hidden under a layer of corrosion products. We have no inkling of the attack till we get a leak or an explosion. So metalurgists, chemists and engineers have sought for years for an accelerated method which will predict the life of a given material under given corrosion conditions. Much has been learned about the mechanism of corrosion, but the better we understand it, the more we see that slight variations in corrosive conditions that are but little or not at all under control, govern the life of the metal. Defeat of the demon corrosion is, therefore, none too easy.

When we come to the high temperature properties of metals, the situation is still different. It will always be difficult to tell exactly how long an oil still will last, for there we have to consider not only the effect of high temperature, but also that of corrosion. In pressure vessels where corrosion is inappreciable, or where it may be controlled by known methods, we are chiefly confronted with the question whether the metal will alter its nature in time and become brittle and unreliable, i. e., whether its structure is stable, and with that of whether or not it will "give," "creep" or "flow" progressively as time goes on.

In a turbine, the clearance is so small, and the danger resulting from a possible failure so great, that an extremely minute rate of flow, inappreciable save by the most refined testing methods, continued over the span of life of a turbine, must be avoided. A flow of 0.01% per year is sometimes considered the outside limit. In other structures, flow makes no great difference; a tank, say, might swell an inch or so in a few months or years, and the dimensional change cause no concern provided the tank remained as strong as it was originally. But many baffling questions arise as to the structural stability of alloys at high temperatures, the causes of embrittlement met in some alloys under some conditions, and the problem whether there is, at high temperatures, any stress at all below which there is actually no plastic flow. At high temperatures even the best alloys somewhat resemble lead at room temperature.

If the service conditions involve oxidation and scaling, then chemical considerations as well as physical properties must be considered. Each case of high temperature service, from the lowly cast iron grate bar to the steam boiler working at 1000° F. and 1500 lbs./in.^{2} steam pressure, and mercury boilers working at 1200° F., has its own problems.

Testing technique is being developed which will ultimately be, if it is not already, adequate to give the needed fundamental information. The chief difficulty in the study of "creep" at high temperatures lies in the high cost of the testing equipment, due to the necessary refinements in temperature control and in measurement of dimensional changes, and in the long time required to complete a reliable test. It is not at all uncommon to use a creep test unit costing $1000 in a steady test for six months upon a single specimen.

No one firm nor group having to do with metals for high temperature use, has time or money enough to start out to collect all the high temperature data it needs in its own work. It is so obviously better to split the work, avoid duplication, and swap the results that the logic of the situation long ago brought about the formation of a Joint Committee on Effect of Temperature on the Properties of Metals (Joint High Temperature Committee for short), consisting of representatives from the American Society of Mechanical Engineers as users of equipment at high temperatures, and from the American Society for Testing Materials as those engaged in producing and testing, as well as using, the alloys. Here competitors joined together to tackle a technical job too big for anyone alone, and the metallurgists worked hand in hand unmindful of rivalry among sales forces. Unselfish effort has been put forth and valuable results obtained. A comprehensive research program dealing with the development and standardization of the new methods and technique required, as well as with the securing of impartial and unbiased data on the properties of some of the most important heat-resisting alloys, is now under way. It is doubtful if the industries benefited by this work fully realize the scope and value of this work. Some of them do. We know one firm which makes a practice of sending its representatives to confer with some of the committee members every few months in the hope of gleaning a few crumbs of information in advance of publication.

The engineer is sometimes, through ignorance, using alloys at temperatures and stresses that make the metallurgist wonder if the use of factors of safety has become outmoded. The strength of the best heat-resistant alloys at the extreme temperatures in service is so low compared to room temperature strength that an error of a hundred pounds per square inch in the true load-carrying ability of the alloy is something of real importance.

Not many years ago, the power plants of the country were using 3 lbs. of coal to produce a kilowatt hour. To-day, the figure is not far from 1 lb. per kwh. And the engineers talk of cutting that to $^1/_2$ lb. per kwh., if only they can get metals to stand the high temperature conditions they must impose. The gas turbine would offer great possibilities if satisfactory alloys could be found.

The oil industry uses metals at high temperatures in modern cracking and hydrogenation processes. Nitrogen fixation and other chemical processes demand suitable alloys for very severe high temperature service.

The metallurgist has a clear duty to develop better alloys for high temperature use, and to collect and disseminate information that will allow the engineer to use the materials now available right up to the permissible limit, and to prevent him from overstepping it. Equally as important as the development of new and better alloys is the securing of accurate data on the high temperature properties of the cheap and easily fabricated ordinary materials of engineering.

As is stated elsewhere in this issue, the Joint High Temperature Committee is sponsoring a symposium in which the needs of various industries for metals for high temperature service and the properties, possibilities and limitations of the available materials is to be fully dealt with. The invitation to utilize this symposium to present the engineering needs, and to find out what the cold facts are on this hot subject should interest many engineers and metallurgists.

Clean Steel

Not many years ago, steel makers were inclined to put a muffler on anyone of their staff who might use the horrid word, "dirty" in regard to steel. They might discuss "sonims" in a whisper, but it was just awful if any customer ever heard or used the words "dirty steel." But the demands of the automobile, and latterly of the aircraft industries changed the situation, and the unreliability of dirty steel became so fully recognized that all makers of quality steel are strenuously seeking ways and means of making their steel cleaner.

Some four years ago, the Bureau of Mines, the Carnegie Institute of Technology and the "Metallurgical Advisory Board," the last representing interested steel makers, started as one of their problems a program of research on "the physical chemistry of steel making," under the direction of Dr. C. H. Herty, with the object of finding out how to make cleaner steel.

Herty and his associates tackled the fundamentals of the problem, such as the solubility of iron oxide in steel under various conditions, methods for determination of iron oxide, methods for determination and identification of other inclusions and the mechanism of deoxidation by silicon, manganese and aluminum. Owing to the temperatures involved, accurate work is extremely difficult, and special technique had to be evolved. The difficulties have been finely overcome, and Herty's group has won international recognition for its work, as evidenced by discussions forwarded for the recent meeting from eminent metallurgists in England and Germany.

That the work is appreciated at home is shown by the fact that the attendance at the annual "open meeting" in Pittsburgh in October was 347 against 67 four years ago. One reason why the work is appreciated is the fact that it has been reported in such fashion that it can be understood by those who seriously want to apply it. The results have been put out in sections small enough and unified enough to be easily grasped, and as fast as produced even though the first rough indications might have later to be revised on the basis of more complete data.

But the thing that has put the job across is the fact that Herty can talk the open-hearth man's language, and can go into a plant, and make a heat to verify the laboratory findings. He does do this, and in fact, the application of the principles worked out has resulted in the production of steel much cleaner than that made by usual present-day practice.

Of course, the interest taken by the industry in this fundamental work has made it possible for various "cure-all' deoxidizers and practices—some not so far from dynamiting a ladle of steel, probably to scare the inclusions away—to get a hearing among those who do not take trouble to study the fundamental work. But such things will fade out of the picture, while work of the type done by Herty remains as the foundation for real progress.

The work to date has cost some $225,000, of which industry has provided about a third. It is calculated by one millman that the probable cost to the mills themselves of scrap due to poor ingot quality from all causes, including dirty steel, and the chipping cost due to it, amount to some $40,000,000 a year. This takes no account of the danger to the public due to unreliable, dirty steel getting into highly stressed parts of machines and structures. It is reasonably to be expected that the application of the principles, which are being clarified by the work at Pittsburgh, will save an appreciable part of this huge sum.

It would be hard to find any metallurgical problem of greater importance and the group who have made this work possible are to be congratulated on the efficiency with which the work has been carried on. It is one of the most notable examples we have in this country of non-competitive research in the Iron and Steel Industry.

Continuation and increase of Government support of the project is thoroughly justified, and ought to be demanded by the industry. We have no doubt but that industry will continue to carry its proper share of the expense. A very small fraction of the savings that will certainly flow from the work would finance it on a much more pretentious scale than is contemplated.

The program now deals with study of slags, etc., in the laboratory, and pays special attention to plant work in the application of the principles that have been developed. It is hoped to continue with the study of the effect of inclusions on physical properties, on gases in steel, on methods of deoxidation in the ladle, etc., after the original five year program is finished.

The eyes of domestic and foreign steel makers are focused on this work. It is exactly the sort of thing that ought to be done as it is being done, on a coöperative, non-competitive basis and it deserves hearty support by the Government, by Carnegie Tech. and by the industry. It should not only be continued, but extended. The world needs cleaner steel, and it is a whole lot nearer to it than it was four years ago.

CORRECTION

To the Editor of Metals & Alloys:

Dear Sir: I wish to correct the wrong impression which might be drawn from the statement on page 756 of my article in the October issue, that: "Butane gas is odorless and poisonous, and has a specific gravity of 1.95; it is heavier than air," due to too broad a use of the word poisonous. Butane gas is not poisonous in the sense that manufactured gas is poisonous, it is non-toxic, and is free from carbon monoxide, but by replacement of air may cause suffocation just as other non-toxic gases, thus producing a "deadly effect," from which the same ultimate result may ensue as from exposure to the toxic manufactured gas—death. My impression of the tendency of a gas heavier than air to collect in pockets and result in smothering, is probably magnified by having been carried out of a gold mine in the Yukon with two other men, years ago, all of us unconscious from not over two minutes' exposure to a deficiency of air resulting from a pocket of carbon dioxide, heavier than air, and having little serious toxic effect except with long exposure. (Peele's *Handbook of Mining*).

Attention is also directed to the phrase: "The addition of an odor has been found desirable to give warning of leaks and thus prevent fatal accidents." Mr. G. R. Benz of the Philfuels Company kindly points out that the odor is added only to avoid fire hazard from leaks, and that butane is non-toxic, being not only harmless itself, but also free from the carbon monoxide content of manufactured gas.

Robert M. Keeney

Hartford, Connecticut.
November 18, 1930

READERS' COMMENTS

To the Editor of Metals & Alloys:
Subject: *"Densite"*

It has come to my attention that I have been quoted as approving or recommending a compound called "Densite" for cleaning steel. I am writing to you to point out that I have never made any such statement regarding this product, and feel that if you will place this communication in your columns it will be seen by people to whom this statement has been made.

Very truly yours,
C. H. Herty, Jr.,
Supervising Chemist,
Metallurgical Section

Bureau of Mines Experiment Station,
Pittsburgh, Pa.
Oct. 24, 1930,

To The Editor of Metals & Alloys:

Dear Sir: An inquiry from one of your readers for further details of the methods discussed in the paper on "Automatic Preparation of Metallographic Samples" in the September issue, by Mr. Guthrie and myself, indicates that the following additional information should be given.

The exact name under which the magnesia polishing powder may be purchased is "Merck's (Blue Ribbon) Reagent Magnesium Oxide free from Sulfates." This material may be purchased from any chemical supply house for about $1.25 per quarter-pound bottle, and can be used as received without any preparation whatever.

Regarding the preparation of the paraffin disc, the procedure is about as follows. The disc should be removed from the polishing machine and mounted in a perfectly horizontal position, which can be determined by the use of a level. Then around this disc should be wrapped a thin metal strip which will serve as sides for the disc, to prevent the molten paraffin from running off. This strip can be either wired on or held on with rubber bands, as desired.

The paraffin used is the ordinary Parowax used for canning purposes. It should be brought up to sufficient temperature to make quite a thin bath and poured onto the disc to a depth of about $^{3}/_{16}''$, allowing the paraffin to thoroughly solidfy before removing the strip from around the disc. If the disc is perfectly horizontal, the paraffin will solidfy uniformly on the disc and will present quite a smooth surface. The paraffin should be further hardened by placing it under a cold water tap and allowing the cold water to run on it for, say, fifteen minutes. Then, replace the paraffin-covered disc on the polishing machine preparatory to cutting the V-shaped grooves in the surface of the paraffin.

It was formerly the practice to use any pointed tool for making these grooves, but it was soon found that any method which would not remove a shaving of paraffin from each groove would only pile up the paraffin on the sides of the groove, to be later pushed back in during the polishing operation, requiring regrooving at very short intervals. So it was necessary to make up a special tool which would actually remove the paraffin from the groove as the groove was made. This tool is made from $^{1}/_{4}''$ square stock about 6″ in length. On one end a V-shaped tooth about $^{1}/_{16}''$ high and $^{1}/_{16}''$ across the base is ground with square shoulders from the base to the bar edge. The back of this tool is relieved much like a milling cutter, resulting in a sharp tooth which, when applied to the paraffin, will remove a V-cut the same size as the tooth. These grooves are cut in the surface of the paraffin disc from the center to the periphery and spaced about $^{1}/_{4}''$ apart at the periphery.

The grinding solution is prepared by mixing liquid soap and water 50-50 and adding the carborundum grain, which will immediately settle out of the soap solution. The proportion of the carborundum grain to the soap solution is unimportant. It is necessary to stir up the mixture in order to charge the brush with both the carborundum grain and the soap solution before applying to the paraffin wheel.

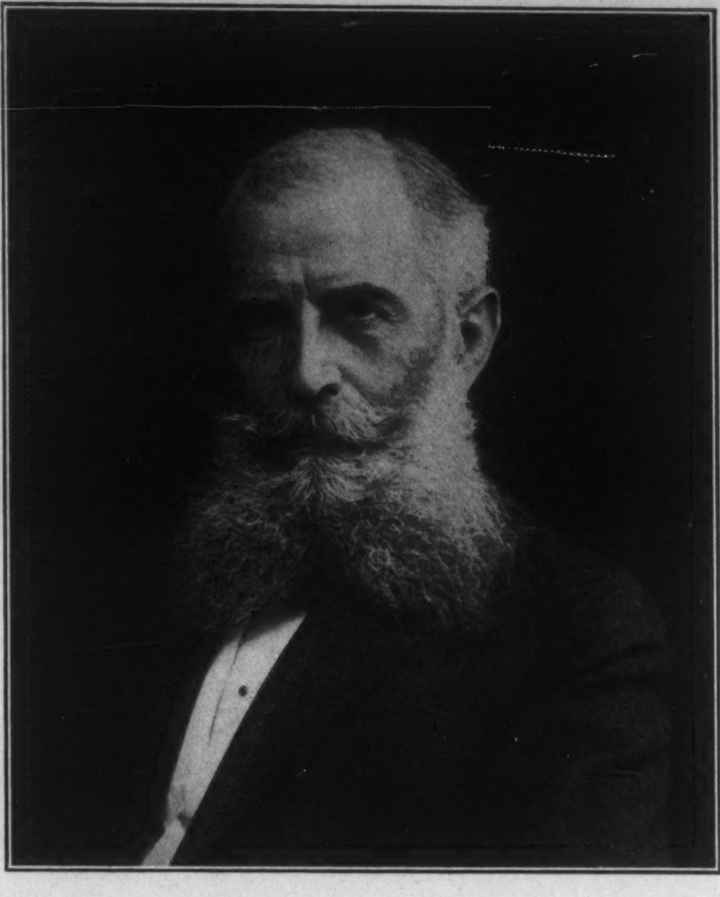
In regard to the 150-mesh alundum wheel, the type of material with which one is dealing will have much to do with the question as to whether or not such a wheel is too fine after redressing. It is not important that this mesh wheel be used exclusively for all types of material, and it may be found that 100-mesh is more satisfactory for some materials. In any case, the next step in the operation, which is the paraffin wheel, will readily accommodate quite a variation in previous preparation.

The authors wish to express their appreciation of the interest in their paper and will be glad to go into the matter further if other inquiries are made.

J. A. Comstock

Peoples Gas-Light & Coke Co.
November 4, 1930

DR. RICHARD G. MOLDENKE



Dr. Richard G. Moldenke, one of the leading metallurgical experts of the United States, died Monday, November 17, 1930 in Muhlenberg Hospital, Plainfield, N. J., following a major operation. He had been ill less than a month.

Dr. Moldenke was sixty-six and lived in Watchung, a suburb of Plainfield, N. J. He was born in Watertown, Wis., in 1864, the son of the Rev. Dr. Edward F. Moldenke, who was at one time pastor of St. Peter's Lutheran Church of New York. He was graduated from the Columbia University School of Mines in 1884 and after two years returned to the school as an instructor. He received his degree of doctor of philosophy in 1887.

For two years afterward he was a member of the United States Coast and Geodetic Survey and for a time was interested in the development of electric power plants.

In 1889 he organized the mechanical and electrical departments of the Michigan College of Mines and in 1890 became associated with the foundry industry, during which he designed and directed construction of the Pittsburgh plant of the Pennsylvania Malleable Iron Company.

Dr. Moldenke wrote a number of books on iron and steel metallurgy, including "The Production of Malleable Castings" and "The Principles of Iron Founding," as well as many papers and addresses. He was for fifteen years secretary and treasurer of the American Foundrymen's Association and had served as consultant to a number of large firms, including the Bethlehem Steel Corporation.

Dr. Moldenke is survived by his wife, two sons, Richard Jr. and Edel; a daughter, Mrs. Paul Hoh of Philadelphia, and two brothers, Dr. Charles Moldenke, author and clergyman of Watchung, and the Rev. Dr. Alfred Moldenke, pastor of St. Peter's Church of New York City.

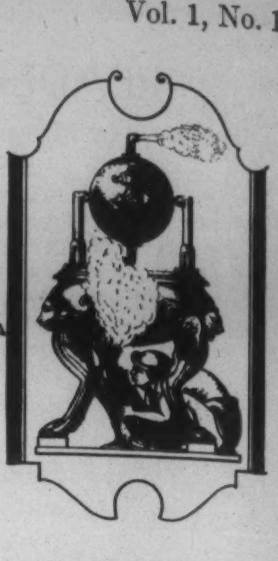
At the annual meeting of the American Society for Steel Treating, the New Jersey Chapter was awarded the "R. M. Bird bell and gavel" for its assistance to the national officers, its excellent organization, and its educational progressiveness.

President Robert G. Guthrie of the A.S.S.T. awarded the bell and gavel to the Chapter, which although only a little more than a year old, is already one of the outstanding Chapters of the Society.

Blakey's Boiler

1766

Metallurgy and the Power Industry



Hero's Engine as pictured by a Grecian

By J. B. Romer*

Records prior to 150 B.C. do not exist and man's first knowledge and use of the expansive force of water vapor is unknown. Hero of Alexandria, in a treatise entitled "Pneumatica," describes devices of others and also describes three methods by which steam might be used directly as a source of power. The third of these, known as "Hero's engine" is described as a hollow sphere supported over a caldron or boiler by two trunnions, one of which was hollow and connected the interior of the sphere with the steam space of the caldron. Two pipes, bent at right angles and open at the ends, formed a connection to the atmosphere. Heat being applied to the caldron, the steam generated passed through the hollow trunnion to the sphere and thence to the atmosphere. By reaction incidental to its escape through these pipes, the sphere was caused to rotate, thus creating the primitive steam reaction turbine.

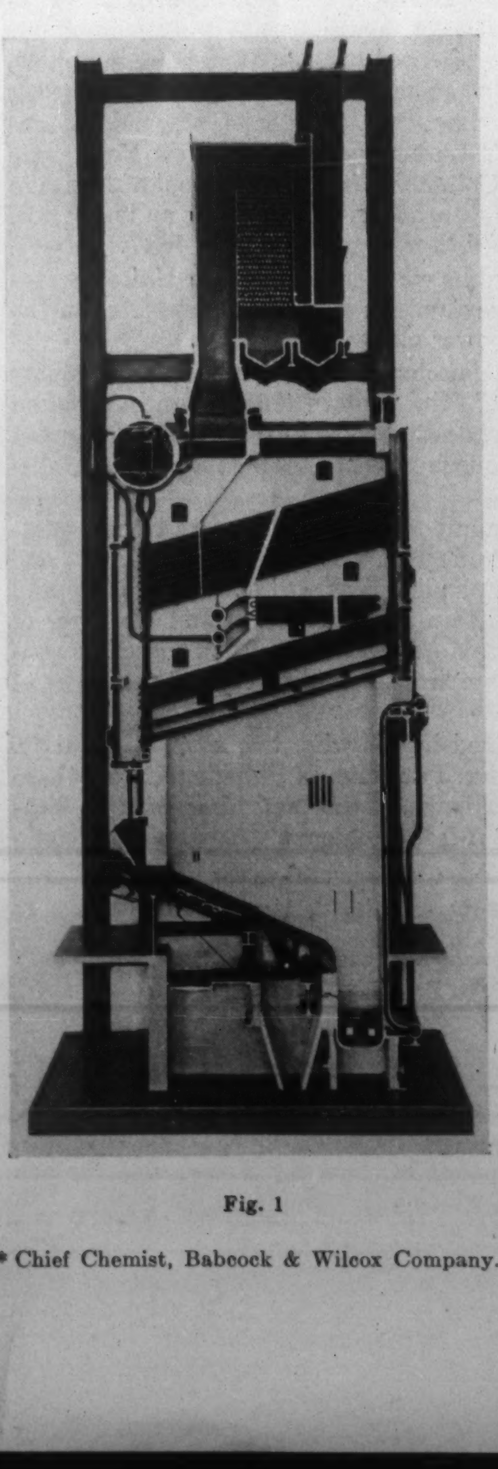


Fig. 1

A water tube boiler was built by William Blakey and patented by him in 1766.

Several tubes alternately inclined at opposite angles were arranged in the furnace, the adjacent tube ends being connected by small pipes.

Blakey's boiler is but one of many developed between Hero's time and the present. Throughout the entire development there has been a steady increase in the pressure.

To-day, the trend in power plant design is to obtain maximum overall efficiency. In some phases, the advances have been extremely rapid, until steam pressures of the order of 1400–1500 lbs. are common and pressures of 2000 lbs. and up to the critical pressure are being given serious consideration. These pressures, of course, mean higher temperatures, and in keeping with this advance, the amount of superheat is being increased. Such conditions have brought the total temperature to a point where steam lines, if they were left uncovered, would glow in the dark. The size of units has likewise increased, no longer is the capacity of a boiler rated at a few hundred thousand pounds of steam per hour, instead, the largest units are over a million pounds of steam per hour.

These conditions impose a severe load on all parts, and the manufacturer, in order to successfully maintain his position, must be prepared, not only to supply what is already in the field, but must be ready to meet a new demand with tried and tested materials.

To-day, a modern boiler burns gas, oil or coal and the latter may be burned on a stoker or as powdered coal. The furnace walls are water cooled blocks. The steam is highly superheated, and the gases, before entering the stack, are well cooled by passing through economizers or air heaters. It is a far cry from "Hero's Engine" and Blakey's boiler to the B & W cross drum and the Stirling type boiler shown in Figs. 1 and 2, respectively.

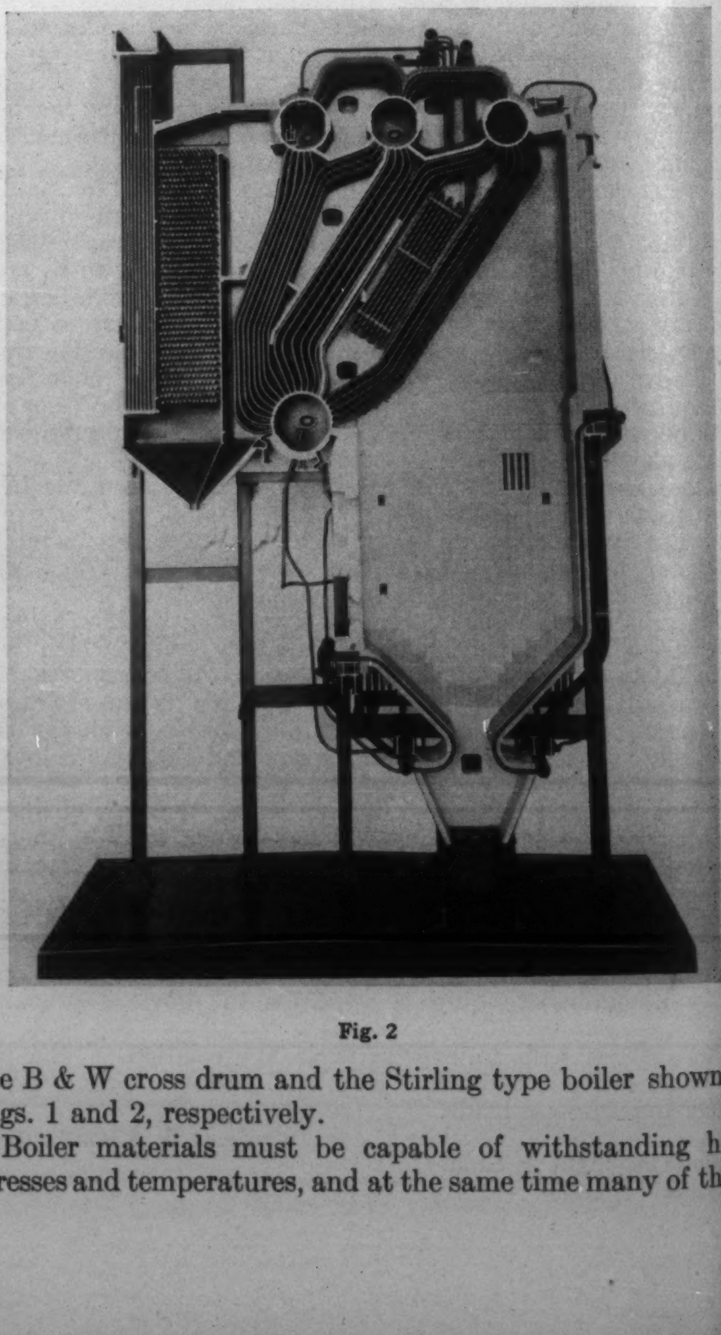


Fig. 2

Boiler materials must be capable of withstanding high stresses and temperatures, and at the same time many of them must withstand the extreme corrosive conditions which frequently develop in various parts of the boiler.

---

* Chief Chemist, Babcock & Wilcox Company.

For many years, low carbon steel possessed all the properties desired by a boiler manufacturer. Its strength was sufficient so that the weight was not excessive and it possessed sufficient ductility that it could be readily formed to the desired shape. With the advent of high temperature and pressure, its value is diminishing. Some of the pressure parts operate at temperatures which are in excess of that which mild carbon steel can withstand. The temperature of superheated steam, in many instances, is such that the aforementioned condition exists in the last passes of the superheater, and as a result, other materials have to be used to give the necessary strength and to prevent oxidation.

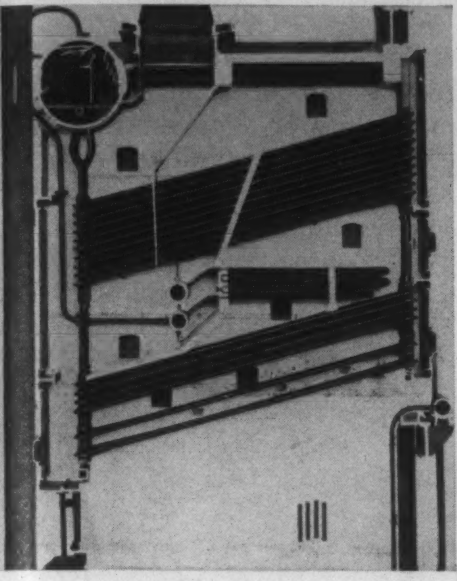


Fig. 3

Fig. 3 shows a superheater located where the temperatures are high.

Another problem is encountered as a result of the loss of strength of steel at these temperatures. This is manifest not only in short time tensile tests, but much more so in long time or creep tests.

Since attention was first drawn to the question of creep of steels, this subject has rapidly developed. It has been found to be of primary importance to the designer of high pressure, high temperature boilers. Creep in a pressure vessel may result in serious damage being done to such a unit. In order to keep a steamjoint tight the amount of creep which is permissible is extremely small.

It has been found that the austenitic chrome nickel alloy will give excellent service for the conditions existing within the last pass of modern superheaters. This alloy resists oxidation at these temperatures and has the added advantage of greater creep strength, as the following table will show.

Creep Stress for a Life of 1% in 100,000 Hours

	Low Carbon Steel lbs./in.^{2}	Nirosta KA2 lbs./in.^{2}
At 900° F...........	7,800	17,500
At 1000° F...........	3,200	11,500
At 1100° F...........	1,500	7,400
At 1200° F...........	550	4,400

The above values are taken from data published by Dr. F.H. Norton of the Massachusetts Institute of Technology, who is working on this problem as a Babcock & Wilcox Research Fellow.

Due to the high content of chromium and nickel and the necessity of maintaining carbon at a low content, this material is necessarily more expensive than the mild steel which has been used for so long. Not withstanding this condition, industry is finding it to be an economic material having a widespread use not only in the power plant field, but also in the oil industry and other places where the conditions are severe. The development of a material that would withstand the severe conditions and which could be produced at a more favorable price level would only be welcome in the event of a favorable ultimate cost.

Unfortunately, the great majority of fuels as fired under boilers contains considerable sulphur and the products of combustion contain sulphur compounds, which, when present in the hotter parts of the boiler, are extremely corrosive.

Oil burning equipment meets severe operating conditions due to high furnace temperatures, radiant heat and high sulphur oils. Fig. 4 illustrates a typical oil burner with a quarter section removed in order to show the details of the construction.

Most superheaters have been placed either above or within the bank of generating tubes and thus have been exposed to the gases after the latter had been partially cooled by the generating tubes. In order to develop certain characteristics, the radiant superheater and the separately fired superheater are being advocated. These two types will be placed within a combustion chamber and thus exposed to the extremely high temperature conditions which accompany powdered coal and oil fuel installations. Here, the demand is for the highest type of metal, where a high temperature will mean a low creep strength, and a high pressure will impose a high unit stress.

Within many parts of the boiler there is need for hangers, etc., which will develop high strength and resist oxidation, for this purpose, a material known as No. 1100 metal has been developed. This is also a chrome nickel alloy. Due to its high strength at high temperatures, it is not readily forged into tubes and shapes, hence it is usually used as a cast metal.

Creep Stress for a Life of 1% in 100,000 Hours

	No. 1100 Metal lbs./in.^{2}
At 900° F............................	22,200
At 1000° F............................	16,300
At 1100° F............................	10,400
At 1200° F............................	6,000

That the maximum efficiency may be obtained, the hot gases leaving the generating unit are passed through economizers or air heaters, or maybe both of these units, in order to cool the gases and at the same time to preheat the feed water or the air being fed to the furnace. At some point in the economizer or air heater, the gas is cooled to the dew point and sulphuric acid is condensed, thus developing a very serious corrosion problem, particularly in those plants using high sulphur Midwestern fuels.

Combating this corrosion is a very serious problem. To be successfully solved, the metal, whether it be pure or an alloy, must either be insoluble under these conditions, or else it must form a film which is insoluble in sulphuric acid. Due to the fact that most metals and their sulphates, the usual products when attacked by sulphuric acid, are soluble in this acid, the problem remains quite acute and the development of a protective coating, which can be efficaciously applied and which will not act as a heat insulator, or the development of

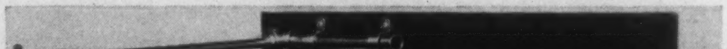


Fig. 4

a solid solution alloy, which is either insoluble or forms an insoluble film, is still awaiting solution.

After the steam has been highly superheated, it is necessary to control its flow to the turbine. This necessitates safety valves and shut off valves, all of which must function at high temperatures without warpage, erosion or seizure. Considerable quantities of monel metal, chrome nickel steel of the S.A.E. 3135 type, and austenitic chrome nickel alloy are being used in valves. Steam piping and valves are attached with various types of flanges, all of which use some form of bolt or stud. At the lower pressures and temperatures, ordinary bar stock was quite sufficient, later, this failed to meet the demand and the use of chrome nickel steel of the type of S.A.E. 3135 rapidly came into use. However, the temperatures are rapidly reaching the point where this material is unable to retain the properties which make it so valuable.

In order to successfully use high pressure-high temperature steam, the turbine manufacturer must supply materials which will withstand erosion, develop sufficient strength that they will not appreciably creep and withstand the high vibratory or fatigue stresses incidental to high speed turbines.

In selecting the proper material, due consideration must be given to the service which will be imposed, for not only must the right material be selected, but it must be properly heat treated so as to develop maximum serviceability. Unfortunately, many of the austenitic alloys do not develop their maximum corrosion resistance as a result of the heat treatment that develops their maximum strength, and this subject is further complicated as some of these materials develop very undesirable properties at certain temperatures, which may, or may not, represent the maximum temperature at which they can be used.

High pressure means high stress in the wall of the containing vessel, and to safely carry this stress, the wall must be of sufficient thickness as to produce a low unit stress. This has been carried to the point where the wall thicknesses are heavy. As a result, fabrication problems are increased, as is the weight of the structure. An alloy steel having the desirable properties of mild steel, and in addition, greater strength, particularly in the medium temperature range, would permit of lighter weight construction with equal safety.

Thus, it may be seen that the metallurgist is eternally confronted with the problem of producing materials that will withstand various combinations of temperature, stress and corrosion, and to do so, he must have a full knowledge of the service requirements, and then he must go further and know how his material will stand up under various conditions, for he can be assured that as soon as the power engineer finds that a certain material will withstand his requirements, then he will raise his requirements in hopes that he may further increase the efficiency of his plant.

DO YOU NEED **BETTER ALLOYS** FOR HIGH TEMPERATURE SERVICE?

If you are confronted with problems relating to the service of metals and alloys at elevated temperatures, or at subnormal temperatures, you may well take the advantage of an opportunity to air your troubles, perhaps to find their solution. If you have developed alloys for such service, you have an opportunity to supply reliable data on their properties applications and limitations.

This opportunity arises from the fact that engineers and metallurgists are going to get together, and tell each other first, just what the situation is as to the engineers' needs for alloys to withstand high temperature and high stresses, and second, what the possibilities and limitations of available alloys are.

This heart-to-heart conference will take place at Chicago in June 1931, at the annual meeting of the American Society for Testing Materials, in a joint session with the American Society of Mechanical Engineers. The program is sponsored by the Joint Committee of these two societies on the Effect of Temperature on the Properties of Metals.

Since most attention is focused on high temperature properties, the Committee is generally known as the Joint High Temperature Committee. This Committee has, for several years been developing and accumulating and correlating data. In 1924, it held a Symposium on its subject, at which was presented the data available at that time. Two bibliographies and several noteworthy papers have been published by the Committee or its members since then.

So much further information is now available, and the demand for more wide-spread distribution of such information has become so general, that the Committee plans a second Symposium to record progress, and discuss the "state of the art." The subject is now so ramified that in order to deal with it adequately, it is necessary to resort to an innovation in technical society symposia.

The various subjects will be fully dealt with in papers which will be preprinted in ample time for digestion before the meeting. Information on individual topics will be colected and summarized by various authors.

The general situation will then be summarized, and the subject thrown open to discussion on all the papers without reading or even abstracting each separate paper. The printed papers will then serve as a full record of known facts, a symposium in black and white, while the session itself will be a broad-gage discussion or "round-table."

The Symposium will deal with the subject from the engineering point of view, one session taking up the needs of the industry, the requirements of different industries and processes, how far and by what alloys they are met at present, what needs are yet unfilled, and especially the trends of development as affecting the materials of construction. That is, that session will put matters squarely up to the metallurgist, indicating to him what he must attempt to provide in the way of improved alloys for service at high and low temperatures.

The second session will give the metallurgists their innings. At it they will describe the good and bad properties of the alloys now in use or ready for use, and will show what the user must do in the design and operation of equipment to make the most of the good qualities and minimize the effects of the poor ones.

The sessions will deal with what is needed and what is available in the way of alloys to resist oxidation, attack of sulphur and its compounds or other corrosive agents, erosion and abrasion, impact and prolonged stress. Dimensional changes with time, such as "creep and growth," and changes in properties, such as loss of strength and advent of embrittlement, will be discussed, as will the coefficient of expansion.

Methods of testing will not be dealt with, save as may be required to define data presented, as that is the function of various sub-committees of the Joint A.S.M.E., A.S.T.M. Committee, and will be dealt with in due course by Committee reports, or by other papers outside the Symposium.

The papers dealing with individual topics will not merely reflect the opinions of the author, but will represent a cross-section of all he can find out on his topic from all sources. This advance notice is designed to stimulate those who may have facts, opinions, queries or points of view to offer, to communicate with those in charge of the topic in which they are interested.

The tentative outline, and the list of those in charge of the topics, follow:

Session 1—Engineering Requirements and Trends for Metals at High and Low Temperatures

1. **The Power Plant Industry.** Boilers, turbines, piping, valves, etc.
   Alfred Iddles, Chairman, Program Committee on Central Station Power, A.S.M.E. Power Division, % Day & Zimmerman, Inc., 112 N. Broad St., Philadelphia, Pa.
2. **The Oil Industry.** Stills, cracking equipment, piping, hot oil pumps, etc.
   E. S. Dixon, Metallurgist, The Texas Co., Port Arthur, Texas. Member Joint High Temperature Committee.
3. **Chemical Industries.** Nitrogen fixation, etc.
   Dr. F. H. Rhodes, Professor of Industrial Chemistry, Baker Laboratory, Cornell University, Ithaca, N. Y.
4. **Metal Industries.** Roasting and smelting, heat-treating, and other furnaces; galvanizing, etc.
   Dean Harvey, Materials Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Chairman A.S.T.M. Committee on Electric Furnace Alloys; and
   N. L. Mochel, Metallurgical Engineer, Westinghouse Electric & Mfg. Co., Lester Sta., Philadelphia, Pa., Sec'y. Joint High Temp. Comm.; member A.S.T.M. Committee on Chromium and Related Alloys.
5. **Automotive Industries.** Pistons, cylinders, radiators, valves and valve springs, bearings, Diesel engines, etc.
   A. L. Boegehold, Metallurgist, Research Laboratories, General Motors Corporation, Detroit, Michigan, and
   J. B. Johnson, Chief, Materials Branch, Wright Field, Dayton, Ohio.
6. **The Ceramic Industries.** Molds for glass, rolls for plate glass, pyrometer tubes, cement kilns, steel for enameling, etc.
   C. E. Williams, Assistant Director, Battelle Memorial Institute, Columbus, Ohio.

The papers of this session will be summarized by L. W. Spring, Chief Chemist, Crane Co., Chicago Ill., Chairman, Committee on Projects, Joint High Temperature Committee.

Session 2—The Properties of Available Materials for High and Low Temperature Service

7. **Zinc Alloys.** Harvey A. Anderson, Metallurgical Development Engineer, Western Electric Company, Hawthorne Sta., Chicago, Illinois; chairman, A.S.T.M. Committee Die Castings.
8. **Aluminum Alloys.** Dr. Zay Jeffries, Consulting Metallurgist, Aluminum Company of America, 2210 Harvard Ave., Cleveland, O.; Pres. Institute of Metals Division A.I.M.M.E.; and
   R. L. Templin, Chief Engineer of Tests, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.
9. **Bearing Metals.** E. R. Darby, Metallurgist, Federal-Mogul Corp., Shoemaker & Lillibridge Ave., Detroit, Mich.
10. **Copper Alloys.** W. H. Bassett, Technical Superintendent and Metallurgist, American Brass Co., Waterbury, Conn., President, A.I.M.M.E.
11. **Wrought Carbon and Low Alloy Steels.** A. P. Spooner, Engineer of Tests, Bethlehem Steel Company, Inc., Bethlehem, Pa.; and
    F. B. Foley, Supt., Research Department, Midvale Co., Nicetown, Philadelphia, Pa.
12. **Cast Carbon and Low Alloy Steels.** Major R. A. Bull, Director, Electric Steel Founders' Research Group, 541 Diversey Parkway, Chicago, Ill.
13. **Cast & Malleable Irons.** H. Bornstein, Metallurgist, Deere & Co., Moline, Ill., chairman, A.S.T.M. Committee on Cast Iron.
14. **Wrought Austenitic Alloys (Ni, Cr, etc.).** E. C. Bain, Metallurgist, Research Laboratory, U. S. Steel Corp., Kearney, N. J.
15. **Cast Austentic Alloys & Other Heat-Resisting Special Alloy Castings.** N. B. Pilling, C. A. Crawford and V. R. Worthington, Metallurgists, International Nickel Co., Bayonne, N. J.
16. **Other Cr Base Alloys.** C. E. MacQuigg, Director, Union Carbide & Carbon Research Laboratory, Thompson & Manley Aves., Long Island City, N. Y. Member, Joint High Temperature Committee.
17. **Other Ni Base Alloys.** N. B. Pilling, Metallurgist, International Nickel Co., Bayonne, N. J.
18. **Rare Metal Alloys.** W. H. Swanger, Metallurgist, U. S. Bureau of Standards, Washington, D. C.
19. **Nitrided Alloys.** Dr. O. E. Harder, Assistant Director, Battelle Memorial Institute, Columbus, Ohio.
20. **Low Temperature Properties of Some Alloys.** Dr. H.W. Russell, Chief Physicist, Battelle Memorial Institute, Columbus, Ohio.
21. **Bibliography of Recent Publications on Effect of Temperature on Metals.** Miss Lois F. McCombs, Bibliographer, Battelle Memorial Institute, Columbus, Ohio.

The papers of this session will be summarized by H. J. French, Metallurgist, International Nickel Company, Bayonne, N. J., chairman, Joint High Temperature Committee.

Suggestions, data, etc. on the topics named should be sent to those listed opposite them. Suggestions for other topics not yet included in the above list should be sent to Dr. H. W. Gillett, Director, Battelle Memorial Institute, Columbus, Ohio.

The oportunity to get this group to secure and present exactly the information that is needed by the engineer, should not be neglected. Promptness in presenting these needs is desirable since it is obvious that as much as possible should be included in the preprinted articles of the Symposium. All these articles are now in preparation.

Domestic Supply of Antimony Is Imported

Except for the antimonial lead produced by lead smelters, virtually all of the domestic supply of antimony is imported, according to the United States Bureau of Mines, Department of Commerce. Usually three-fourths, and formerly a much larger portion, of this supply is imported in the form of metal, and the remainder is imported largely in the form of liquated antimony sulphide, antimony ore and oxide of antimony. Substantial quantities of the element, however, are contained in the imported antimonial lead, or "type metal," as it is called. Only small quantities of antimony salts are imported. Metallic antimony is still known in the trades as regulus, but this archaic term is gradually falling into disuse. Liquated sulphide is variously known as crude antimony or crudum, needle antimony and antimony matte, and like the metal is imported chiefly from China. It is used principally in the manufacture of oxide. Antimony ore has likewise been used to some extent for making oxide, but it is also employed by primary lead smelters and secondary smelters for making antimonial lead. Only high-grade ore (preferably containing in excess of 60% of antimony and free from deleterious impurities, especially lead and arsenic) can be used economically for the manufacture of oxide of antimony. Recently the imports of ore have come principally from Mexico and South America. Antimonial lead is an alloy containing 12 to 20% antimony; it is imported mainly from American smelters in Mexico. Antimony oxide is imported chiefly from China. The manufacture of the oxide now seems established in the United States on a firm basis. The demand is improved, and manufacturers are now investigating additional outlets, notably the paint field.

Additional details are given in the statistical report, "Antimony in 1929," by Paul M. Tyler, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 5 cents.

The Technique of Radiography by Gamma Rays

By Charles S. Barrett,* Roy A. Gezelius* and Robert F. Mehl*

GAMMA rays can be used in place of X-rays as a means of non-destructive testing of castings and welds for internal defects. It was shown by Mehl, Doan and Barrett[1] that radiographs can be taken through ordinary sections of steel in a few hours, using as sources of γ-rays amounts of radium readily available at hospitals in the larger cities. The greater penetrating power of γ-rays compared with X-rays was pointed out, and examples reproduced of radiographs taken through thicknesses well beyond the range of usefulness of X-rays at present available.

The apparatus necessary for γ-ray radiography is very simple. A small container of radioactive material is supported rigidly in front of the specimen to be inspected, and X-ray films in suitable holders fastened to the back of the specimens.

Fig. 1 shows the experimental arrangement used for taking four simultaneous radiographs of specimens built up of plates. A small glass funnel was used to hold the bulb of radium emanation in the center of the group. In Fig. 2 a similar funnel is hung on strings in front of an arm of a forge press, and a film is placed behind it, without removal of the piece. Fig. 3 shows the method that was used to explore a large cylindrical casting. Here the source of γ-rays was mounted on a stand within the casting, and films were fastened opposite the source, on the outside. It would have been possible to take radiographs simultaneously on a belt of films extending completely around this casting had it been desired. One of the operators is shown holding a lead-lined box containing an eight-inch diameter bulb of radium emanation.

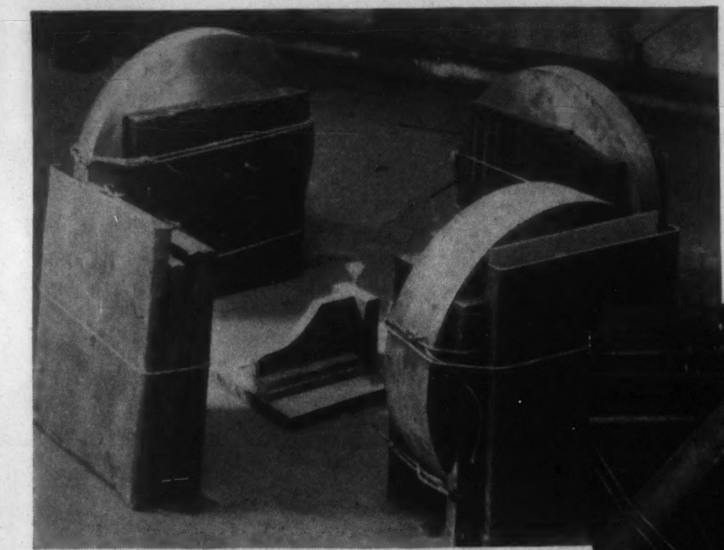


Fig. 1—Arrangement Used to Radiograph Experimental Specimens

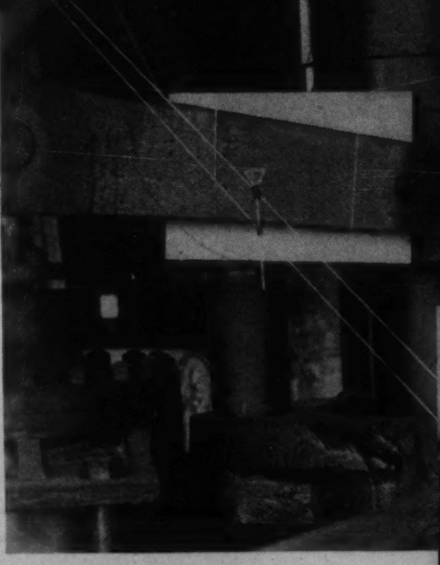


Fig. 2—A Glass Funnel Supported by Strings Holds Radium in Front of an Arm of a Forge Press for Radiographic Inspection in Situ

The characteristics of the γ-ray method make it especially applicable to radiographic work through thicknesses above 2" or 3" of iron such as are found, for instance, with castings for high pressure steam power plants. When portability is necessary the method is again very appropriate since no high voltage electrical apparatus is required. A lead lined room is unnecessary as the simplest protection for the operator from the rays is merely to remain at a distance from the radium during the exposure, and to handle the radium with forceps.

It was the purpose of the previous paper to demonstrate the possibility of γ-ray radiography by exhibiting actual radiographs through a large range of thicknesses of steel, and by theoretical arguments. Such interest has been shown in this possibility, especially among the makers and users of large castings, that a definite technique for taking suitable radiographs is already in demand. From the cost standpoint, the importance of eliminating guesswork is obvious. Radium is not so cheap that its use can be a success in practice if any considerable percentage of radiographs taken with it are failures, or if advantage is not taken of means of increasing the efficiency of the process.

The present paper is an attempt to give definite recommendations and quantitative data for taking γ-ray radiographs. It seems advisable to discuss the physics involved in the technique in some detail; this is done under the headings, "The Source of Gamma Rays," "The Effect of Rays on Films," "Exposures Necessary" and "Scattering of Gamma Rays." In view of the simplicity of both apparatus and operations involved in γ-ray inspection, highly skilled labor seems unnecessary. A simple presentation of a suitable technique is, therefore, in order, and while it may be lacking under the headings mentioned, the division "Operations in Practice" is intended to fill this need.

The difficulty of reproducing radiographs for publication is well known. A tremendous range of densities may be satisfactorily recorded on a film, but only a few appear on a print. To illustrate points in the discussion below, however, it is necessary to reproduce some actual radiographs regardless of the quality of the reproduction. This has been attempted in Figs. 4 to 9,

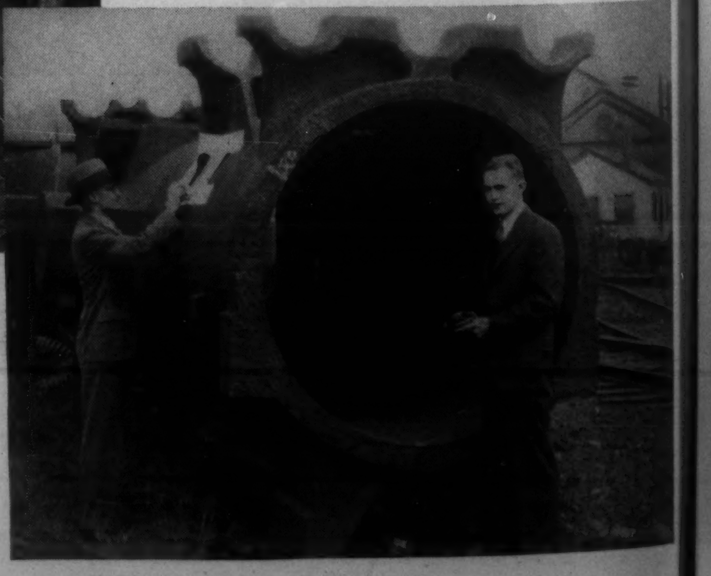


Fig. 3—Radiographing a Large Cylindrical Casting. Radium Is Held on a Stand Inside and Films Fastened Outside

---

Published with the permission of the Navy Department.

* Division of Physical Metallurgy, Naval Research Laboratory, Anacostia, D. C.

[1] Radiography by the Use of Gamma Rays. *Transactions American Society for Steel Treating, Preprint,* Chicago, 1930.

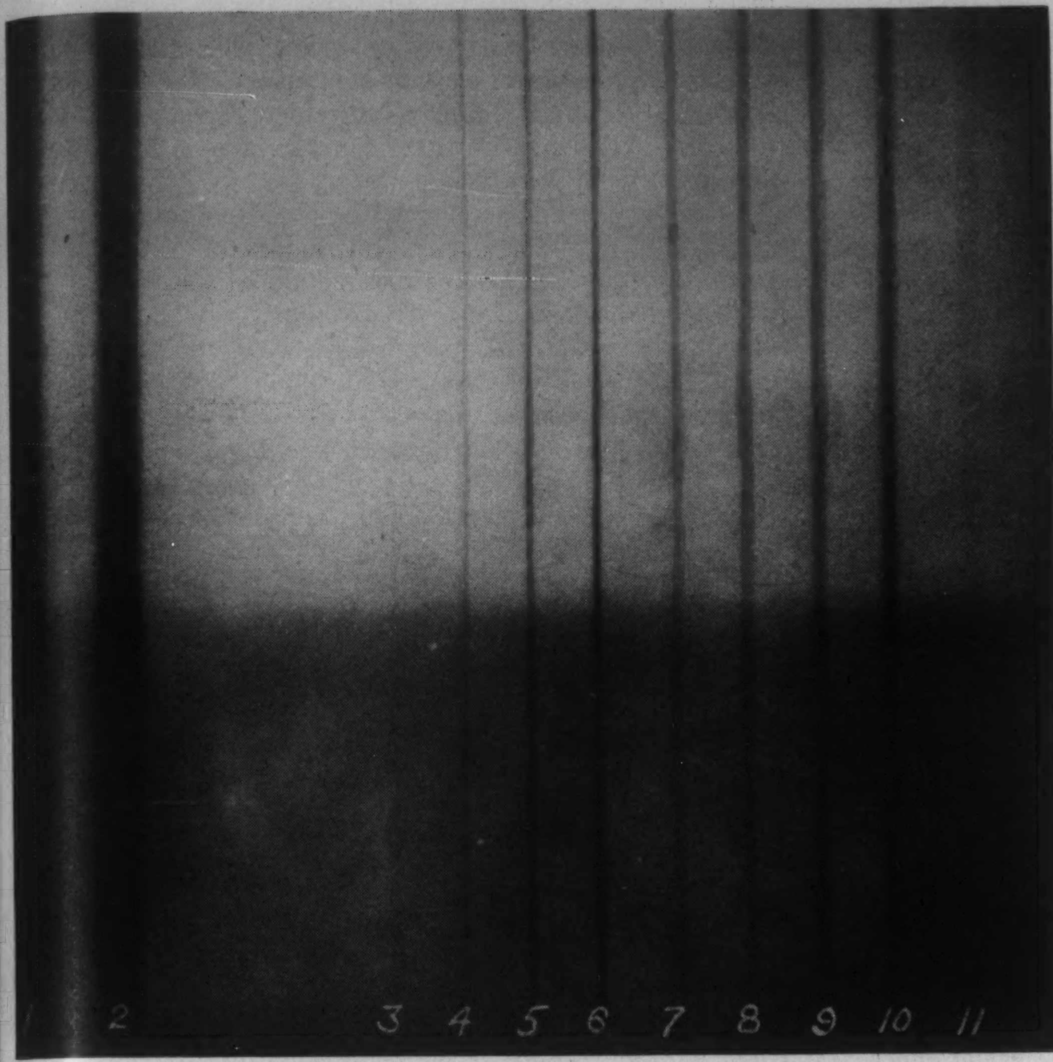


Fig. 4—Radiograph of Slotted Steel Plate Arranged as Shown in Fig. 1. Total Thickness 4"; Distance, Source to Film, 18"; Exposure 3050 Milligram Hours Using 3 Lead Intensifying Screens with 2 Films; Dimensions of Slots as Follows:

Slot number	1	2	3	4	5	6	7	8	9	10	11
Width in mm.	13	6	1	1	1	1	2	2	2	2	3
Depth in mm.	13	13	2	3	6	12	2	3.5	6.5	12	2

through photography of the original films placed on a viewing frame and illuminated by diffuse light from the rear. In some cases increased contrast has been obtained through the use of Process film and contrast printing; in other cases it was necessary to reduce contrast and suffer a corresponding loss of detail. No retouching has been done.

The Source of Gamma Rays

The only radioactive material of practical importance seems to be radium; there are considerable amounts[2] of this distributed in several cities in the U. S. and used for medical purposes.

Radium decomposes at a constant rate into the gas radium emanation, which in turn produces a series of decomposing solids, some of which give off γ-rays.[3] The strength of these rays is proportional to the amount of radium emanation present. If the emanation is left in contact with the radium from which it forms, it builds up until equilibrium is reached, when its rate of formation equals its rate of decay, and its strength is then proportional to the amount of the radium. The amount of emanation in equilibrium with one gram of radium, as measured by the intensity of the γ-rays emitted, is called a Curie.

Radium emanation may be pumped from the parent radium, and sealed in small glass bulbs. In this form its strength decreases so that the intensity I of X-rays at any moment is $I = I_0e^{-\lambda t}$ where t is the time interval that has elapsed since the intensity was I_0, and λ is a constant, equal to 0.007551 when t is measured in hours. Table 1 gives values hourly for $\frac{I}{I_0}$.

Either radium or radium emanation may be used for radiography, but the necessary exposure times are different. When radium is used one has a source of a constant intensity, and the exposure obtained is proportional to the product of intensity and time, I_0t. With emanation as a source the exposure is porportional to the integral of intensity with respect to time, i. e.

$$\int_0^t I\,dt = I_0\int_0^t e^{-\lambda t}\,dt = \frac{I_0}{\lambda}(1-e^{-\lambda t}).$$

With the use of this formula Table 2 has been computed, giving the number of hours' exposure necessary with emanation to produce a result equal to a given number of hours exposure with radium, when the strength of the emanation in millicuries at the beginning of the exposure is equal to the number of milligrams of radium. For example, if one desired exposure of 1200 milligram hours, it could be had with 100 milligrams of radium in 12 hours, 200 milligrams in 6 hours, etc.; but reference to Table 2 shows that if one started with 100 millicuries of emanation it would require 12.6 hours, or starting with 200 millicuries 6.1 hours would be necessary.

A less accurate method of calculating exposures is to assume that the decay is linear with time and that the mean strength

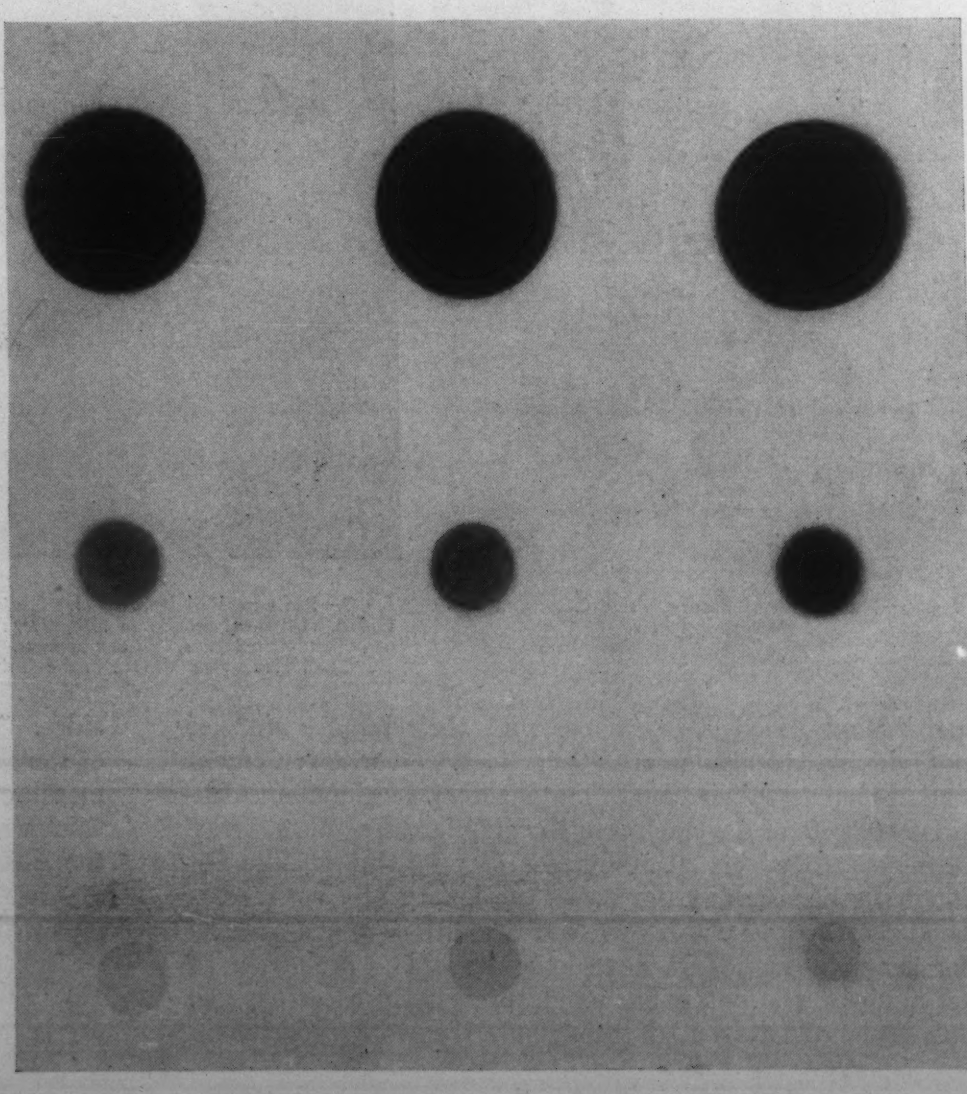


Fig. 5—Radiograph of Drilled Steel Plate Shown in Fig. 1, with Total Thickness $1\frac{1}{2}$"; Distance, Source to Film 18"; Exposure 175 Milligram Hours Using 3 Lead Screens and 2 Films; Dimensions of Holes; Top Row, 1" Diameter, $\frac{3}{4}$", 1" and $1\frac{1}{2}$" Deep; Middle Row, $\frac{1}{2}$" Diameter, $\frac{3}{8}$", $\frac{1}{2}$", $\frac{5}{8}$" Deep; Bottom Row, $\frac{1}{2}$" Diameter, $\frac{1}{16}$", $\frac{1}{8}$", $\frac{3}{16}$" Deep

---

[2] Figures do not seem to be available as to the amount of radium in the country. No radium has been produced in this country since 1925, but the U. S. Department of Commerce has estimated that 45 or 50 grams were imported during the years 1924–1929, and we understand it is being imported at an increasing rate.

[3] Practically all the gamma rays effective in radiographic work arise from the disintegration of Radium C.

Table 1—Decay of Radium Emanation*
(for $\lambda = 0.007551$ hrs.; Half Life = 3.825 days)

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
t	$e^{-\lambda t}$	t	$e^{-\lambda t}$	t	$e^{-\lambda t}$	t	$e^{-\lambda t}$
0	1.0000						
1	0.9925	13	0.9064	25	0.8278	37	0.7560
2	0.9850	14	0.8996	26	0.8216	38	0.7504
3	0.9786	15	0.8929	27	0.8155	39	0.7448
4	0.9703	16	0.8861	28	0.8093	40	0.7391
5	0.9629	17	0.8795	29	0.8032	41	0.7336
6	0.9557	18	0.8729	30	0.7973	42	0.7282
7	0.9485	19	0.8662	31	0.7911	43	0.7225
8	0.9413	20	0.8597	32	0.7852	44	0.7171
9	0.9343	21	0.8533	33	0.7793	45	0.7117
10	0.9272	22	0.8468	34	0.7734	46	0.7064
11	0.9203	23	0.8405	35	0.7676	47	0.7010
12	0.9134	24	0.8343	36	0.7620	48	0.6960

* Meyer-Schweidler, "Radioactivität," Teubener, Berlin (1927) page 419.

of the emanation during an exposure is simply the average of the initial and final strengths. The errors in such calculations are negligible in practice unless exposures are many hours long.

Table 2—Comparison of Exposure Times in Hours for Radium and for Radium Emanation of Equal Initial Strength

Radium	Emanation	Radium	Emanation	Radium	Emanation	Radium	Emanation
1	1.0	11	11.5	21	22.8	31	35.4
2	2.0	12	12.6	22	24.0	32	36.6
3	3.0	13	13.7	23	25.3	33	37.9
4	4.0	14	14.8	24	26.5	34	39.3
5	5.1	15	15.9	25	27.7	35	40.6
6	6.1	16	17.0	26	29.0	36	42.0
7	7.1	17	18.2	27	30.2	37	43.4
8	8.2	18	19.3	28	31.5	38	44.8
9	9.3	19	20.5	29	32.8	39	46.2
10	10.4	20	21.6	30	34.0	40	47.6

Effect of Rays on Films

In both X-ray and γ-ray work where but a minute fraction of the radiation passing through a film is absorbed by the emulsion, any method of increasing the photographic effect of the rays is of great practical importance. Eastman Super-speed Dupli-Tized X-ray films, with their large grain size and double emulsion are very fast. Over-development further increases their speed. Satisfactory development technique consists of developing in the standard Eastman X-ray Developer to which 20 milligrams of potassium iodide per liter have been added, for twice the length of time recommended for ordinary X-ray work at the various temperatures.[4] For example, at 65° F. development may be prolonged to ten minutes, the potassium iodide preventing excessive fog. This technique was used throughout the work reported in this paper.

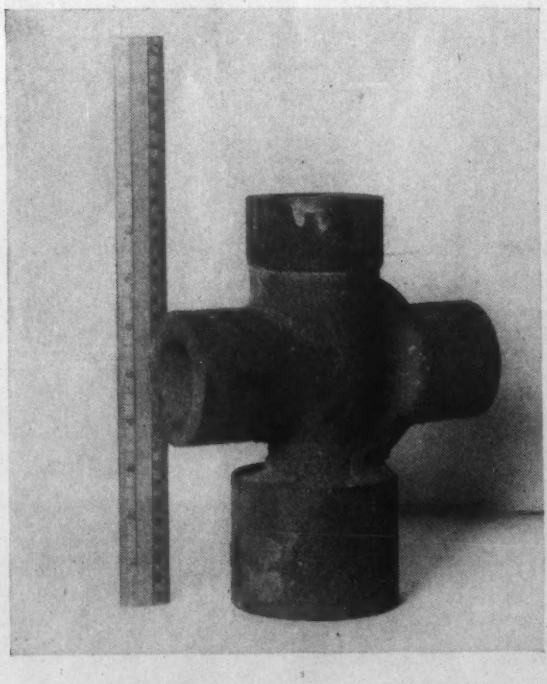


Fig. 6—Photograph of Bronze Valve Casting Radiographed in Fig. 7

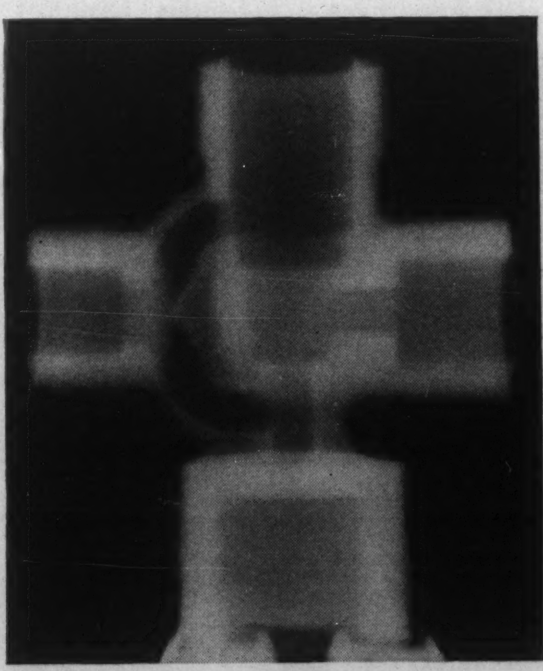


Fig. 7—Radiograph of Bronze Valve Casting Shown in Fig. 6. Distance, Source to Film, $27^1/_2$", Exposure 1600 Milligram Hours; 2 Lead Screens, 1 Film. Several Small Flaws Are Visible in the Original Film

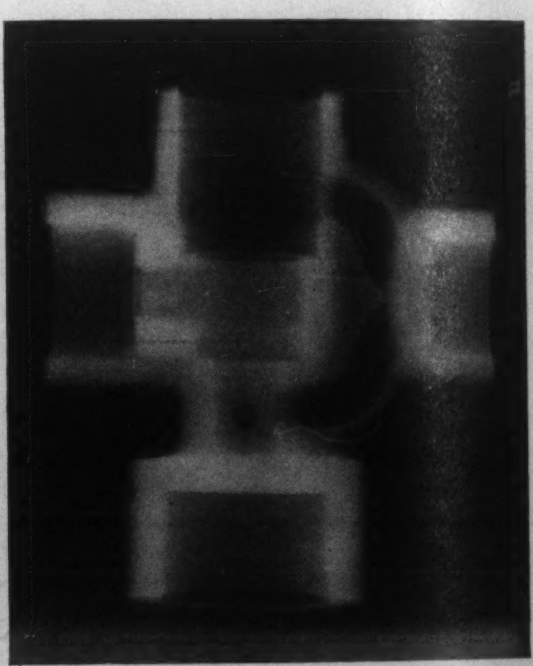


Fig. 8—Radiograph of a Machined, Bronze Valve Casting. Distance, Source to Film, $27^1/_2$", Exposure 1600 Milligram Hours; 2 Lead Screens, 1 Film (See also Front Cover)

Secondary electrons ejected by the γ-rays are more completely absorbed in the emulsion than the γ-rays themselves so that a copious emitter of secondary electrons in contact with the emulsion can considerably increase the efficiency of the film. Lead foil[5] placed on both sides of the film was found to shorten the exposure times for γ-rays as it is commonly known to do for X-rays.

Definite measurements are available on the intensity of this secondary electron emission under various conditions. Eve[6] measured with an electroscope the intensity of the electron emission from sheets of different elements for γ-rays filtered through 2 cms. of lead, separating the emission from the 2 sides of the sheets. The ionization in his electroscope due to electrons coming out of the side of the sheet upon which the γ-rays were incident as plotted in Fig. 10 as the "Incidence" curve, while the curve marked "emergence" gives the ionization caused by emission from the side of emergence of the γ-rays.[7] The preponderance of emission in the emergence direction for light elements has its explanation in the quantum theories of radiation. As the atomic number of the screen is decreased, an increasing proportion of the secondary electrons is made up of electrons recoiling under the impact of the quanta of γ-rays, which they deflect, or "scatter." These recoiling electrons obey the laws of conservation of energy and momentum in the impact and thus always go in the forward direction, in fact with γ-rays nearly all proceed at an angle less than 45° from the direction of motion of the primary γ-ray. With the heavier elements, on the other hand, the recoil electrons become few in number compared with photoelectrons. Photoelectrons result when the γ-ray quanta are absorbed instead of deflected, and have a distribution in space quite different from that of the recoil electrons so that the total emission from heavy elements is approximately the same from the incidence and emergence sides. The emergence ionization as a function of thickness of the sheet is plotted in Fig. 11 for aluminum and lead from measurements by Bragg.[8] The ionization increases with thickness until the electrons starting at the incidence side of the sheet are unable to reach the emergence side; further increase in thickness simply reduces the intensity of the γ-rays without adding to the number of electrons emitted.

---

[4] A chart of standard developing times is given in "X-rays in Industry," Eastman Kodak Co. (1929).

[5] The foil used was General Electric X-ray Corporation's "X-ray Foil' 0.006" thick.

[6] A. S. Eve. *Philosophical Magazine of London, Edinburgh & Dublin*, Vol. 18 (1909) page 275.

[7] No importance should be attached to the actual values of the ionization plotted here, for an unknown but constant amount must be subtracted from these values to correct for ionization from causes other than those here discussed.

[8] W. H. Bragg & J. P. V. Madsen. *Philosophical Magazine of London, Edinburgh & Dublin*, Vol. 16 (1908) page 918.

On the basis of Figs. 10 and 11 then, the best foils to put in contact with double-emulsion films for γ-ray work would be lead for the side farther from the radium, and lead or aluminum on the near side; the lead foil should be 0.2–0.4 mm. thick for maximum effect, and the aluminum 2 mm. or more. An actual test with X-rays through 4″ of steel with 2 mm. aluminum, 0.15 mm. lead and 0.3 mm. lead on the radium side of films proved that lead is preferable to aluminum both for speed and definition; 0.15 mm. of lead appeared slightly more effective than 0.3 mm.

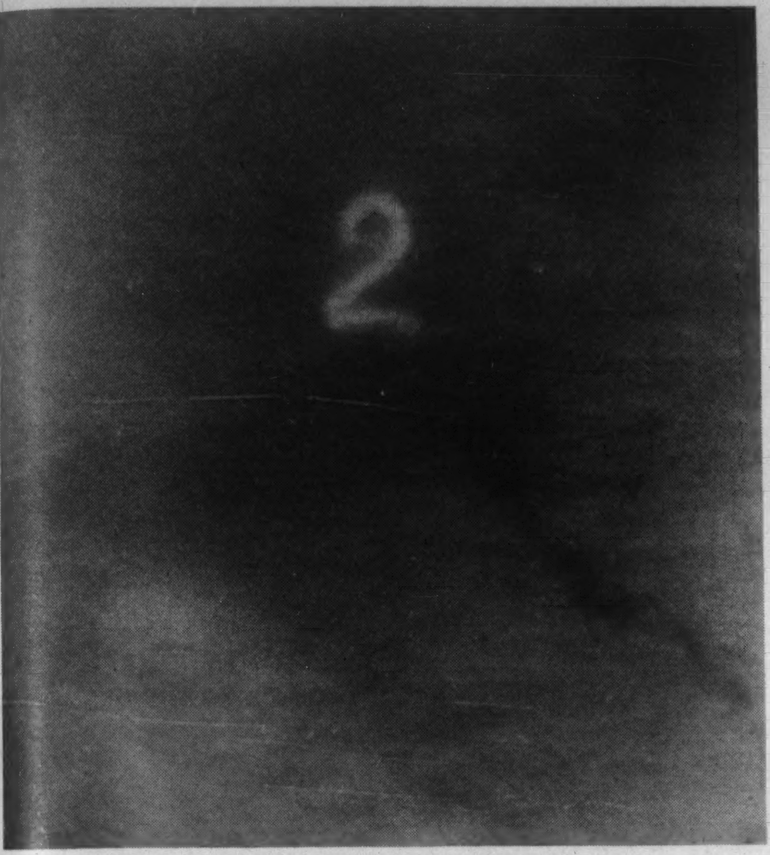


Fig. 9—One of the Radiographs of the Large Casting Shown in Fig. 3. A Long Crack, Slightly Obscured by Streaks Due to Irregularities in the Surface of the Casting, Is Seen Below and to the Right of the Lead Identification Number "2." Exposure 5100 Milligram Hours with 3 Lead Screens, 2 Films; Distance, Source to Film, 31″

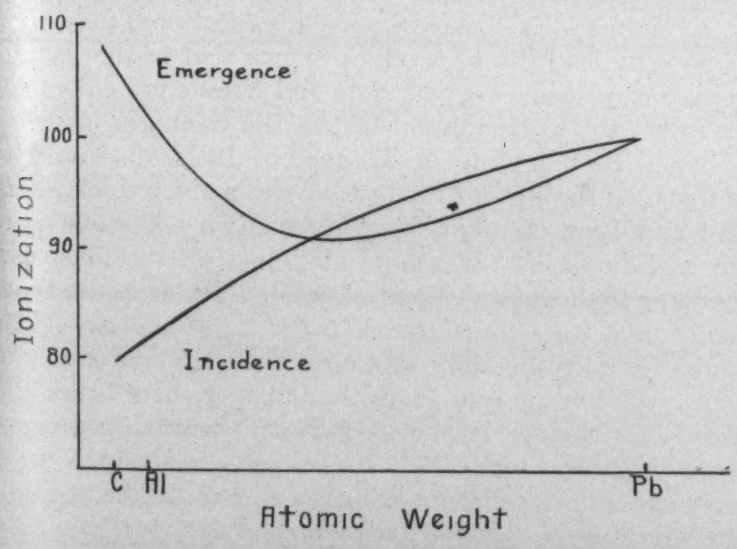


Fig. 10—Ionization Produced by Secondary Electrons from Screens of Various Atomic Weights When Radiated by γ-Rays from Radium (A. S. Eve)

Materials which fluoresce under the action of γ-rays can be made into effective intensifying screens as has been done for X-ray radiography. Calcium tungstate screens are satisfactory in the γ-ray region, although their effectiveness in shortening exposure times for γ-rays is not as great as for high voltage X-rays. When used with X-rays their intensifying action increases with the hardness of the rays; that this increase does not continue into the γ-ray region of wave-lengths is seen from the measurements of Fig. 12. Scattered γ-rays reaching the film from the rear, in radiographic work, are considerably longer in wave-length than the original γ-rays and might fall within the range of greatest intensifying action for calcium tungstate screens. If this were the case it would be doubly important to shield radiographic films from side and rear scattering when using such screens.

The characteristics of Eastman Superspeed Dupli-Tized X-ray films under various conditions are shown in Fig. 13. The method of obtaining the data was as follows: A lead cylinder 8″ in diameter with a hole 1″ in diameter extending through it was used to collimate a beam of γ-rays from 250 millicuries of radium emanation placed at the bottom of the hole. The films under test were placed on the top of a block of iron 1″ thick placed over the hole, and were 9″ from the radium. Exposures of 1 to 32 minutes were made and the films over-developed with the technique described above. Densities of the unexposed film and the exposed spots were calculated from measurements on a Kipp and Zonen Microphotometer by taking the logarithm to the base of the ratio of intensities of light passing through an undeveloped, fixed, washed and dried film, to the intensity of the light passing through the film whose density was desired. That is, the density was taken as

$$\log_e \frac{\text{light incident on the emulsion}}{\text{light transmitted by the emulsion}}.$$

The density due to the fog alone (amounting to about 1.15) was then subtracted from the densities of the exposed portions for each film and the difference plotted against the exposure time in Fig. 13. The results show films surrounded by two Patterson screens to be the fastest of those tried, then in order, one Patterson screen and one lead screen, two lead screens and finally plain film without screens. Radiographic exposures made with two Patterson screens require about 0.6 the time required without screens, while with two lead screens this fraction is about $^3/_4$.

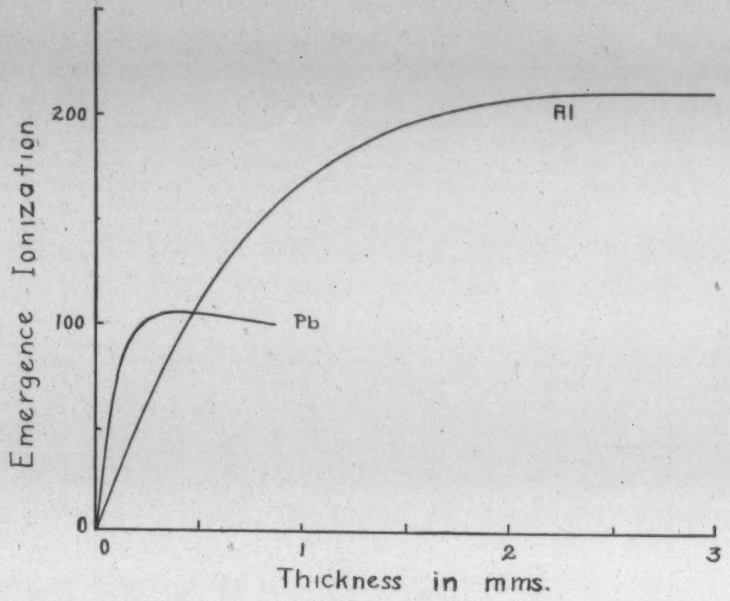


Fig. 11—Ionization on the Emergent Side of Screens of Various Thicknesses When Radiated by γ-Rays from Radium (Bragg and Madsen)

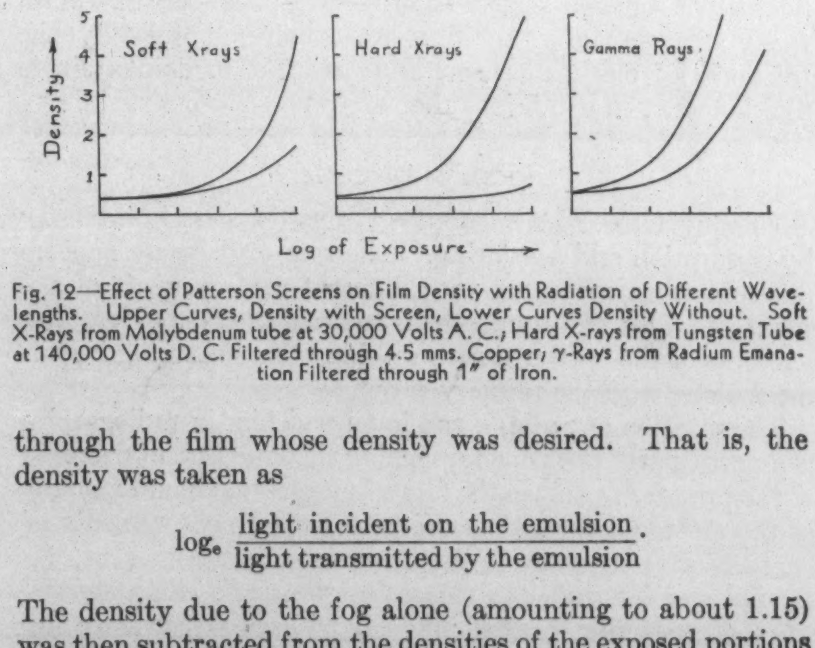


Fig. 12—Effect of Patterson Screens on Film Density with Radiation of Different Wave-lengths. Upper Curves, Density with Screen, Lower Curves Density Without. Soft X-Rays from Molybdenum tube at 30,000 Volts A. C.; Hard X-rays from Tungsten Tube at 140,000 Volts D. C. Filtered through 4.5 mms. Copper; γ-Rays from Radium Emanation Filtered through 1″ of Iron.

In all our radiographic tests we have used duplicate films. There is a considerable advantage in making a simultaneous exposure on two films; not only may the exposure be shortened, but perhaps more important than that, the irregularities in the emulsions originating in manufacture and subsequent handling do not occur in the same spots on both films and are, therefore, averaged out. A great deal more confidence is felt in interpreting a faint marking as caused by a defect in a radiographed specimen if the same marking is seen on two films. The advisability of using more than two films appears questionable to the authors, however. The "confidence factor" does not increase appreciably, and the density due to the fog alone, with all the films combined, becomes too great—at least with the developing technique used in this work. Of course, the film costs also increase with the multiplicity of films used.

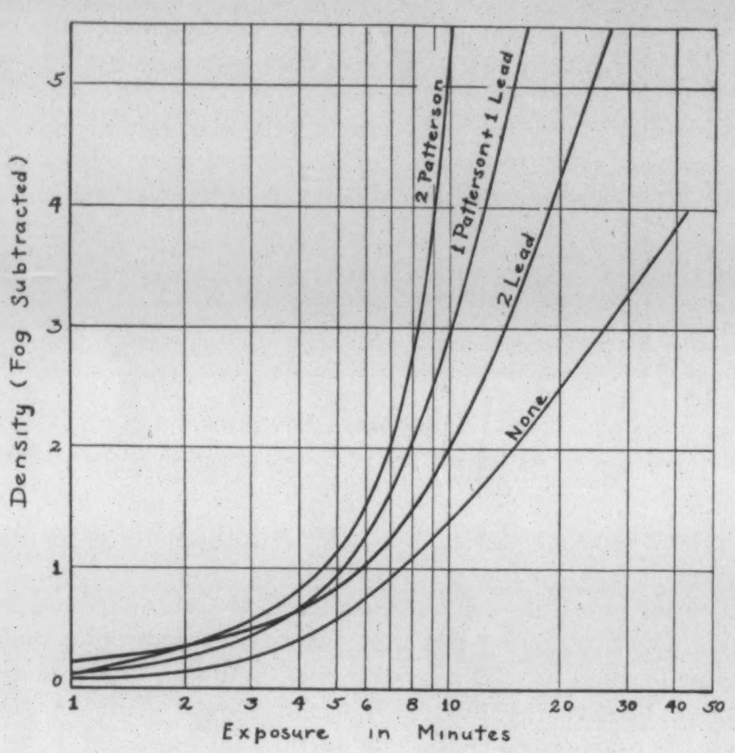


Fig. 13—Characteristics of Films with Different Intensifying Screens for γ-Rays from Radium Emanation Filtered through 1" of Iron

Two arrangements found convenient when using a pair of films are: lead—film—lead—film—lead, or when using fluorescent screens: screen—film—lead—film—screen. With these arrangements the films are separated only by the thickness of one lead sheet, and are contained in a single film holder, two conditions that are obviously desirable.

Exposures Necessary

Upon penetrating a substance γ-rays decrease in intensity by absorption and scattering. The rate of decrease appears different when measured with different arrangements of apparatus. This has been shown to be the effect of varying amounts of the scattered rays reaching the measuring instrument along with the primary rays.[9]

The position of radium, specimen and film in radiography is a particularly poor one for getting the true rate of decrease of the primary ray since the film receives a maximum amount of the scattered rays. Therefore, accurate measurements of true absorption, made with the absorbing screen near the radium and far from the measuring device to eliminate the effect of scattering, cannot properly be used to calculate the intensity striking the film in a radiographic exposure.

Absorption measurements under conditions approximating those of radiography were made by Soddy and Russell,[10] K. W. F. Kohbrausch[11] and others. It was found that the intensity of a ray of original intensity I_0 after passing through a thickness x of a metal of density ρ was

$$I = I_0 e^{-\mu x} = I_0 e^{-\left(\frac{\mu}{\rho}\right)\rho x}$$

where μ is the linear absorption coefficient and $\left(\frac{\mu}{\rho}\right)$ the mass absorption coefficient. Some values found for these coefficients are given in Table 3. Soddy and Russell found a constant value of μ in lead from 2 to 22 cm. thick, and similarly found constant values over large ranges of thickness in other materials. Later observers were able to detect a hardening of the rays as they penetrated greater thicknesses, caused by the more rapid absorption of the softer components, and resulting in a progressive decrease in μ with increasing thickness, an effect doubtless hidden from the earlier investigators by the presence of considerable scattering in their work. Taking the simple exponential equation above as representing absorption in radiography, the exposure time required to give a certain density on a photographic film behind x cms. of metal varies with the thickness according to the relation

Table 3—Absorption Coefficients for γ-Rays from Radium According to Soddy and Russell

Metal	μ(cm.$^{-1}$)	μ/ρ
Fe	0.304	0.0399
Cu	0.351	0.0398
Brass	0.325	0.0389
Al	0.111	0.0401
Pb	0.495	0.0434

$$t = t_0 e^{\mu x} = t_0 e^{\left(\frac{\mu}{\rho}\right)\rho x}$$

where t_0 is the time required with $x = 0$. The derivation of this equation assumes (1) that a constant source of intensity is used, (2) that the effect on a film is the product of intensity times time, a valid assumption and (3) that the film is completely protected by lead shields from scattered rays reaching it from the rear (excited by primary rays striking the walls, floor, etc.).

As there was some doubt as to just how well the above formula and values of Table 3 would serve to establish radiographic exposure times, it was decided to determine exposure times under actual conditions.

Steel plates 12" square and steel disks 16" in diameter were arranged about a holder of radium emanation as shown in Fig. 1. Films were shielded from γ-rays scattered from walls and floor by lead sheet $^1/_8$" thick shown tied to the back of the piles of plates. Various slots and holes were cut in the plates next to the emanation to test the thickness of defect that could be detected. A distance of 18" from source to film was used throughout the test. With a given thickness of plates and type of intensifying screen two exposures were made and the density measured at points on the films corresponding to the full thickness of metal. The exposure times actually used were transformed to the times that would be required for corresponding exposures with 100 milligrams of radium. Plotted on semi-logarithmic paper these times and densities, for a given thickness, gave two points on a curve of the type shown in Fig. 13. These points located the time-density curve with sufficient accuracy since only the position of the curve along the time axis, not its shape, is affected by the thickness of the absorbing plates. The time required to give any desired degree of blackening could then be read from the curve. Such exposures were used that the desired point lay either between the two used, or very close to one.

The proper amount of blackening for radiographs has been studied in detail by Neef[12] but it is difficult to believe that the optimum density for viewing small changes in density of a film is independent of the intensity of the viewing light, as he appears to assume. For viewing two superimposed films each of which show rather more fog than usual because of the method of overdevelopment used, the optimum density recommended by Neef can hardly be given much weight.

---

[9] For summaries of this work see Rutherford, "Radioactive Substances and Their Radiations." Cambridge (1913) pages 258–263; Meyer & Schweidler, "Radioactivität," pages 149–156; *Handbuch der Experimental Physik*, Vol. XV, pages 70–74.

[10] F. Soddy & A. S. Russell. *Philosophical Magazine of London, Edinburgh & Dublin*, Vol. 18 (1909) page 620. Mr. & Mrs Soddy, & A. S. Russell. *Philosophical Magazine of London, Edinburgh & Dublin*, Vol. 19 (1910) page 725.

[11] Summarized: *Handbuch der Experimental Physik*, Vol. XV, page 71.

[12] Th. Neef. *Zeitschrift für Technische Physik*, Vol. 6 (1925) pages 208–216; reviewed by Glocker. "Materialprüfing mit Röntgenstrahlen," Springer, Berlin (1927) pages 65–69.

We have chosen a density, including fog, of 2.20 (in natural logarithms); with this blackening flaws 2–3% of the specimen's thickness are seen with specimens from 2" to 6" thick.[13] This density is suitable for viewing two superimposed films simultaneously and is also satisfactory for viewing a single film in close contact with white paper by reflected light.

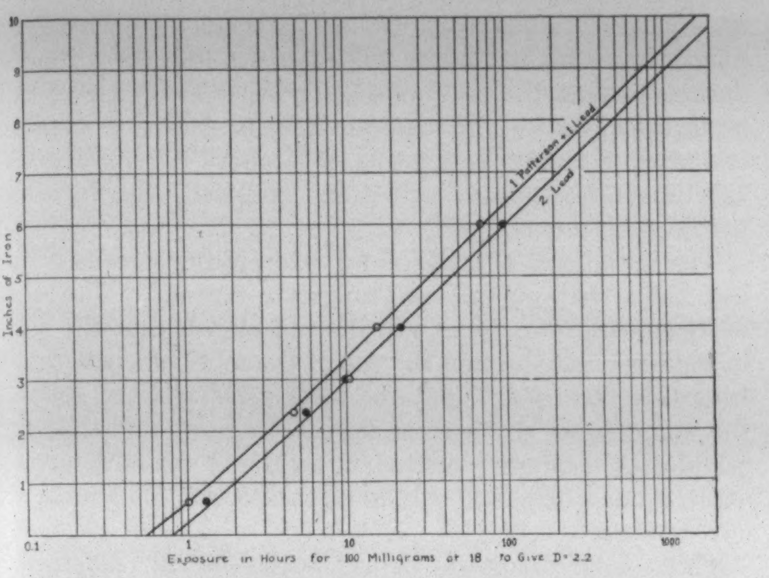


Fig. 14—Exposure Times for Radiography with γ-Rays from Radium. Conditions Assumed: Constant Source of 100 Milligrams at 18" from Film Using Intensifying Screens Indicated. Resultant Density (with Overdevelopment) Suitable for Simultaneous Viewing of Two Films

The results of the test are given in Fig. 14. For thicknesses above two inches the slope of the curves has been made to correspond to a linear absorption coefficient of $\mu = 0.304$ in agreement with Soddy and Russell's value (Table 3). Curves are given for two arrangements of screens and one density; data for other screens or other densities can be obtained from these by multiplying the exposure times by suitable factors (equivalent to a displacement of these curves along the axis of abscissas).

It will be seen from Table 3 that the mass absorption coefficient, $\left(\frac{\mu}{\rho}\right)$, has nearly a constant value for different elements. From the exposure time equation above it is seen that the following convenient approximate rule can be formulated: the exposure necessary for x inches thickness of a metal of density ρ is the same as that necessary for $\rho x/7.8$ inches of steel, where 7.8 is the density of steel. This was tested with aluminum ($\rho = 2.7$) by giving a 5" thickness the exposure necessary for $2.7 \times 5/7.8 = 1.73"$ of iron; the resulting blackening was that expected within the limit of accuracy of the experiment. This rule is convenient when making up a plaster to coat the surface of an irregular casting for the purpose of eliminating shadows of surface defects from the radiograph. Any plaster will do that has the same density as the casting.

The exposure necessary for a radium-to-film distance of d inches can be obtained from the exposure at 18" by multiplying the latter by $(d/18)^2$. The distance used in practice will depend upon the number and size of objects that are to be radiographed at one time and upon the definition—the sharpness of the image—that is desired. The smaller the source and the greater its distance from the defect, the greater the sharpness of the defect's shadow. Another important advantage obtained with a greater distance is a more uniform intensity over the area of the film. For the most economical use of radium, the objects to be tested should be placed about the radium to cover the greatest possible fraction of the total solid angle about it; they may be placed at such distances that the various thicknesses reach their completed exposures in the same number of hours. When the whole of the spherically radiated energy from the radium is used in this way the cost per specimen is independent of the dimensions of the arrangement. It has been found that in many cases overnight exposures are most convenient. Table 4 gives necessary radium and radium emanation strength for overnight exposures for various thicknesses and distances calculated from the data given above.

Table 4—Strength of Radium in Milligrams and Initial Strength of Emanation in Millicuries Required for an Overnight Exposure (15 Hours) at the Distances and through the Thickness Indicated, with Two Lead Screens, Dupli-Tized Superspeed X-Ray Films, Over-development, and Film Density of 2.20

	Source to film, distance in inches							
Thickness of	12		18		24		30	
iron in inches	Ra	Em	Ra	Em	Ra	Em	Ra	Em
1	5.3	5.6	12.0	12.7	21.3	22.5	33.3	35.2
2	12.6	13.3	28.3	29.9	50.3	53.1	78.6	83.0
3	29.3	31.0	66.0	69.7	117.3	123.8	183.3	193.6
4	63.0	66.6	141.6	149.6	251.6	265.8	393.1	415.3
5	132.5	140.0	298.2	315.0	530.0	560.0	828.1	875.0
6	296.5	313	666.6	704	1185	1252	1852	1956

Due to the lower absorption coefficient of γ-rays it is easier to obtain suitable radiographs of specimens of irregular thickness with them than with X-rays. Exposures for irregular pieces should be figured on the basis of the thick sections rather than the thin ones, for densities considerably greater than the one recommended above are not detrimental (except in possibly preventing simultaneous viewing of films). Underexposures, on the other hand, are unsatisfactory. Gamma-ray pictures are less contrasty than X-ray pictures because of the lower absorption coefficient of γ-rays. While this limits the usefulness of γ-rays for very thin specimens it is not serious for most work.

Scattering of Gamma-Rays

The radiographs reproduced in Figs. 7 and 8 were taken without precautions against the direct rays striking the film at the edges of the casting, and without shielding from scattering from the other castings arranged about the radium simultaneously, yet there is an almost complete lack of halation at the edges of the casting's shadow. A radiograph with X-rays under the same conditions would have shown a great deal of halation. There are two reasons for the difference. In the first place, ratio of the intensity of the unabsorbed rays to that of the rays that have passed through the casting is much greater for X-rays than for γ-rays. Since the amount of scattering from adjacent objects and from the part of the film itself exposed to the direct rays is proportional to this ratio, it is greater in the X-ray case. In the second place the angular distribution of the intensity of the scattered rays is a cause of less halation with γ-rays. The intensity of scattering as a function of angle is plotted radially in Fig. 15 for γ-rays filtered through 1 cm. of lead.[14]

The proportion of scattering at large angles increases with increasing wave-length and is one of the causes for the need of careful shielding of the film when using X-rays. The Bucky diaphragm, a device of multiple slits placed between the specimen and the film and very useful in radiography of the human body with the long wave-lengths necessary for that purpose, could not be expected to add much to the quality of γ-ray radiographs. Its purpose is to prevent radiation scattered at an angle greater than a certain given angle from reaching the film. It is, therefore, an artificial method of producing a distribution of scattered rays of the favorable type shown in Fig. 15 and would naturally be most effective when the original distribution differed most from this, i. e., with soft X-rays.

---

[13] In the absence of scattering, the ability to detect a hole is independent of the thickness of the specimen, since it leads to an increase in the intensity reaching the film by a factor of $e^{\mu d}$ where d is the depth of the hole and μ the absorption coefficient of the metal. In practice this relation does not hold, for scattering is present and is a function of the thickness.

[14] A. H. Compton. *Philosophical Magazine of London, Edinburgh & Dublin*, Vol. 41 (1921) pages 749–769. This distribution has a satisfactory explanation in the quantum theory of the Compton effect, the most recent form of the theory being that of Klein and Nishina (O. Klein & Nishina. *Zeitschrift für Physik*, Vol. 52 (1929) pages 853, and *Nature*, Vol. 122 (1928) page 398) which predicts the observed intensities accurately when a wave length of 0.01 A.U. is assumed for the γ-rays. For earlier theories see A. H. Compton. "X-Rays and Electrons." Van Nostrand Co. (1926) pages 296–305.

The wave-length of the scattered rays is another factor to be considered, for it is much greater than that of the primary rays. If the primary wave-length be taken as 0.010 A. U., then a ray scattered at 90° has a wave-length of 0.034 A. U. and at 180°, 0.058 A. U. With this increase in wave-length goes a decrease in the hardness of the ray. This is so pronounced that at large angles of scattering the rays are no harder than high voltage X-rays.

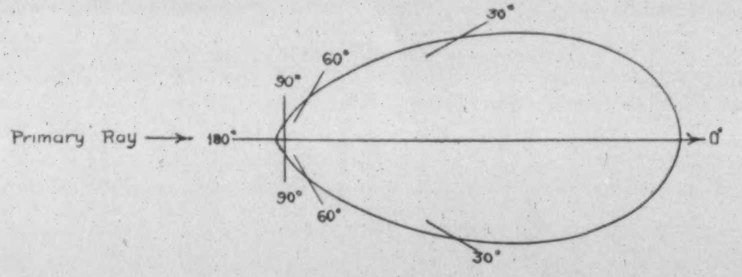


Fig. 15—Distribution in Angle of Intensity of γ-Rays from Radium Scattered by Iron (A. H. Compton)

Knowledge of these factors enables a calculation to be made of the area of film which will be fogged by the scattering from a given point in a specimen being radiographed. Taking measurements of Compton's[15] we have estimated the relative intensity of scattered γ-rays reaching different points at the rear of a lead sheet 1" thick, assuming a small element of volume on the radium side of the sheet as the only source of scattering. Because of the distribution-in-angle of intensities, the softening upon scattering, the different thicknesses traversed by the scattered rays and the weakening according to the square of the distance from the source of scattering, this element of volume can cause fogging over a circle only an inch or so in diameter, as shown in Fig. 16. (The intensity of the primary ray is not indicated in the figure.) While this example represents a simplified case not found in practice, it is sufficient to show an important point; namely, that a specimen of great length and breadth can be radiographed with practically no more fogging from scattering arising in the specimen than one would experience with a small specimen of the same thickness.

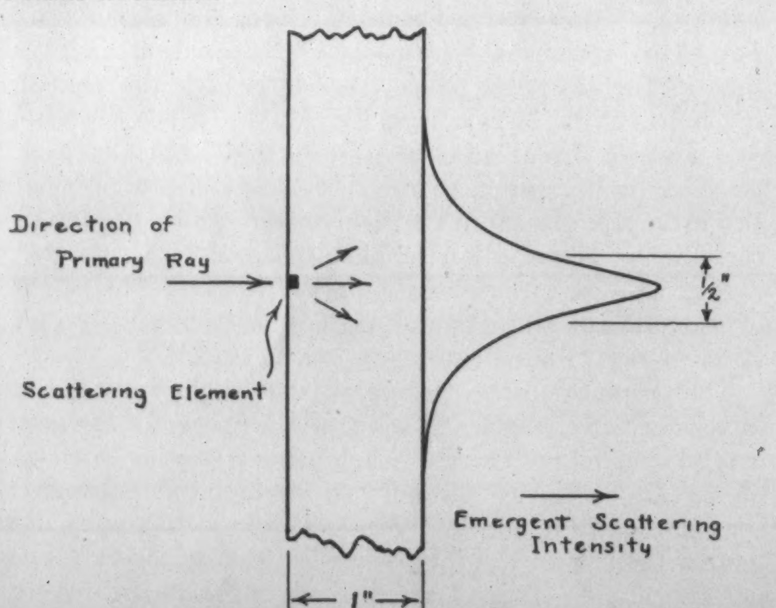


Fig. 16—Distribution of Intensity over the Back of a Lead Block, of γ-Rays Scattered by an Element of Volume in the Front Surface of the Block

For best results films should be shielded from scattered rays reaching them from the rear (originating in the walls and floor of the room), although the amount of this is not excessive. Fig. 4 taken through 4" of steel had part of the film protected from this rear scattering by an $^1/_8$" thickness of lead; another part was protected by a $^1/_4$" thickness. As is seen the fog was reduced by the $^1/_8$" sheet, but no further reduction was effected by the additional $^1/_8$".

Operations in Practice

An imaginary case will serve to illustrate the process of taking γ-ray radiographs with the technique recommended above and will indicate the simplicity of the method. Let us assume that radiographs are to be taken of two castings, one of steel of maximum thickness (in the direction it is desired to send the rays) of 4", the other of bronze of maximum thickness 3", and suppose that the source available for the work is radium emanation of strength 350 millicuries at the time the exposure is to start, enclosed, say, in a small needle-shaped container.

The initial cost of lead foil for intensifying screens is much less than that of calcium tungstate screens. The choice between these two types will depend on whether the saving in radium costs through the use of the more efficient calcium tungstate screens will pay for their greater initial cost. In this example we will assume lead foil is used, and that properly designed film holders are on hand. A desirable arrangement in each film holder is to alternate two films and three lead screens.

The source assumed, being needle-shaped, amounts to nearly a point source if viewed from the ends, so the most advantageous position for the two castings is in line with the axis of the needle. Their distance from the needle will now be considered. The greater the sharpness desired in the radiographs, the greater must be the distance from source to film and the smaller must be the dimensions of the source. Larger films require greater distances than small films, in order to have uniform blackening over the surface of the film. Suppose comparison with previous results indicates the source to film distance should be at least 18" (a distance found satisfactory in the work in this Laboratory). The exposure may then be calculated for the larger casting using this distance.

From the chart of Fig. 14 the exposure for 4" of steel at 18" with lead screens and Eastman Dupli-Tized X-ray film is seen to be 21 hours for 100 milligrams of radium, or $21 \times \frac{100}{350} = 6.0$ hours for 350 milligrams. The equivalent exposure using radium emanation of 350 millicuries strength at the beginning of the exposure is obtained from Table 2 and is 6.1 hours.

The bronze casting may be placed at 18" and its exposure time calculated, or it may be placed at such a distance that it will require the same length of time as the steel casting. The latter scheme is often more convenient and will be assumed in this illustration. The thickness of 3" assumed for bronze is first to be reduced to its equivalent thickness of steel by multiplying by the density of the alloy and dividing by the density of steel. An alloy of Cu 90%, Sn 10%, weighs 548 lbs./cu. ft.[16] and cast steel weighs 490 lbs. /cu. ft.[16] so the equivalent thickness of steel is $3 \times \frac{548}{490} = 3.35$". Again referring to Fig. 14 an exposure of 12.8 hours is required with 100 milligrams radium at 18", therefore, $12.8 \times \frac{100}{350} = 3.66$ hours with 350 milligrams at 18". The time of exposure varies as the square of the distance from the source, so to make the exposure in 6 hours with radium (6.1 hrs. with emanation) requires a distance d given by

$$\left(\frac{d}{18}\right)^2 = \frac{6}{3.66} \text{ or } d = 23''.$$

A simple, rigid support of glass, wood or other light material is arranged for the source at a convenient place, preferably at a distance from large masses of matter in order to reduce scattering, and the castings placed at their proper distances from the source. Films in their holders are fastened so as to receive the shadows of the castings, and sheet lead is placed at the sides and rear of the films as a protection against scattered rays. The radium emanation is placed in its holder with tongs as quickly as possible after it arrives. The operator may then leave, returning at the conclusion of the exposure to remove the emanation. Obviously the source of γ-rays should not be left in the vicinity of the films before or after exposure. Development of the films in the dark room is a simple operation if proper film hangers and developing tanks are used. Development by time and temperature is always best.[17] The exposure times given are minimum values when films are developed twice the usual time with 20 milligrams of potassium iodide are added per liter of standard X-ray developer. If ordinary development is used or if greater density of films is desired, longer exposures than those given above will be needed.

---

[15] A. H. Compton. *Philosophical Magazine of London, Edinburgh & Dublin*, Vol. 41 (1921) page 749.

[16] *National Metals Handbook of the A.S.S.T.* (1930) page 17.

Duplicate radiographs may be fastened together with paper clips and viewed simultaneously, to increase the visibility of defects and to eliminate irregularities in the films.

Summary

A technique for taking radiographs by means of γ-rays is given with charts and tables of exposure times for radium and for radium emanation.

Factors influencing the quality of radiographs and the rapidity of photographic action with γ-rays are discussed.

---

[17] For dark room technique see "X-rays in Industry," Eastman Kodak Co. (1929).

HERBERT H. DOW

Herbert H. Dow, president of the Dow Chemical Co., died at the Mayo Clinic, Rochester, Minn., on October 15, quite unexpectedly and after but a brief illness. He had gone to the clinic on September 2 for a general examination, the preliminary results of which were quite encouraging to his family and friends. Dr. Dow was born at Belleville, Ontario, Canada, February 26, 1866. He was educated at the Case School of Applied Science, which bestowed its honorary degree of doctor of engineering upon him in 1924. He was best known for the great success which came to him as an inventive chemist and executive.

Willard Dow Heads Chemical Plant

At a special meeting of the board of directors, October 21, Willard H. Dow was appointed president and general manager of The Dow Chemical Company, Midland, Michigan, to succeed Dr. Herbert H. Dow, deceased.

For eight years Mr. Dow has been a member of the Board of Directors, and for the past four years he has acted as assistant general manager. For the last three years he has also been assistant treasurer.

His intimacy with organization executive policies strengthened by eleven years of practical chemical experience fit him particularly well to head this $30,000,000 chemical organization.

Mr. Dow is a graduate of the University of Michigan, having received a Bachelor of Science degree in Chemical Engineering from that university in 1919. His practical work in the plant has made him familiar with the manufacturing processes used in producing more than 150 chemical products. His first act under his new title was to state that "the already well-defined policies of progressive research and the building of processes well apace of the ever-changing modern demands will, I am sure, continue to be the distinguishing factor in The Dow Chemical Company of the future."

Dowmetal, an alloy of Magnesium Metal, has been developed on a commercial basis at the Dow Plant. This metal is $^1/_3$ lighter than aluminum, and can be machined, welded, rolled or extruded on a production basis.

The Modern Steel Casting

R. L. Collier in a paper before the Steel Founders' Society of America summarizes the advantages of cast steel construction as follows:

1. Steel castings do away with complicated assembly and fabrication, saving labor.
2. Integral cast steel construction increases rigidity and resistance to vibration.
3. Homogeneous metal through the piece or part necessitates fewer calculations as to strength of parts required to resist a specific strain or meet a specific condition.
4. Heat treating is extensively practiced, which relieves all stresses in the casting, refines the grain structure of the metal and develops maximum beneficial properties.
5. Various alloys are in common use whose physical properties can be made to exactly fit special conditions of service.
6. Because of their strength, durability, resistance to wear, abrasion, heat and corrosion, oxidation and distortion, steel castings frequently cost less per pound of life than other materials on which initial cost may be lower.

New Brown Indicating Pyrometer Controller

The new Brown Model 801 Indicating Pyrometer Controller can be supplied as an automatic control pyrometer, resistance thermometer, tachometer or CO_2 meter. Outstanding advantages of this instrument are: 1. Reading observed directly on 6" scale; 2. Index on scale for setting to exact control point; 3. Control point instantly and easily adjustable; 4. All wiring terminals and motor enclosed. No danger when used in the presence of explosive or inflammable gases; 5. Mercury switches up to 30 amperes capacity, eliminating the necessity of relay equipment. Make and break occurs in sealed glass tube. No danger of spark causing explosion; 6. Suitable for "on and off" or "three position" control through switches, valves, dampers, etc.; 7. Available with patented safety device which opens furnace circuit if thermocouple or wiring fails, preventing burning out furnace; 8. High internal resistance, insuring accuracy; 9. Automatic internal compensation eliminating cold junction errors when instrument is supplied as a pyrometer; 10. Simplicity and ruggedness insures minimum of attention.

New Building for Niagara Falls Smelting & Refining Corporation

On October 18th the corner stone for the new building, being erected by the Niagara Falls Smelting and Refining Corporation, was laid.

A large group of stockholders, directors of the company, employees and friends were present. After the ceremony had been completed, the group inspected the building and a lunch was then served.

This building is the first unit planned for the expansion of the Niagara Falls Smelting and Refining Corporation and its subsidiary, the Eureka Metal Products Corporation.

One-Hundredth Issue

With the November 1930 issue, *Oxy-Acetylene Tips* has reached the one-hundredth milestone. One hundred months, only a little over eight years, and yet that period has witnessed a development in the oxy-acetylene industry which might well constitute a distinct achievement even though it had required a hundred years. It is difficult to believe that so short a time has been required to develop this industry to its present important position.

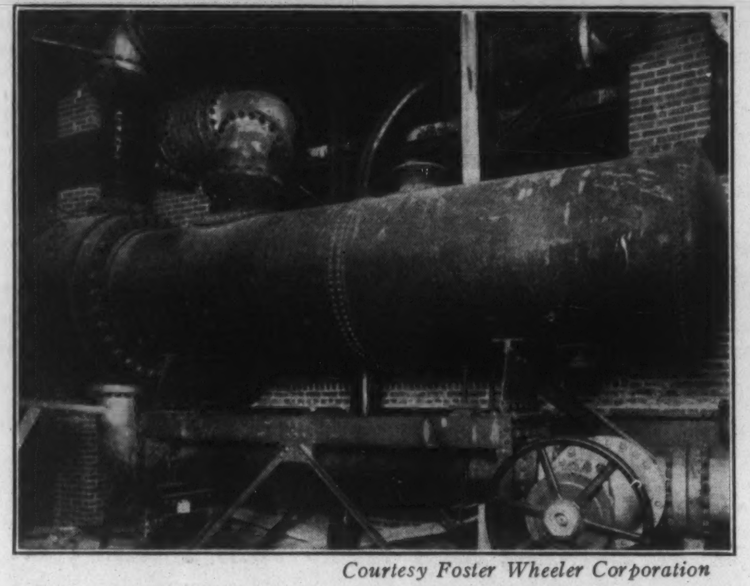
Oxy-Acetylene Tips was founded in August 1922, at a time when industry was beginning to extend the impetus which the war had given to the oxy-acetylene process. Originally the magazine was planned as a house organ to carry new ideas on the oxy-acetylene process to members of the Sales and Service organizations of the publisher. Before many issues had appeared it began to attract the attention of customers who had seen copies and many requests were received asking that copies be sent regularly. With the November 1923, issue a broader policy of distribution was placed into effect and the statement of purpose which still appears at the editorial masthead was adopted.

To-day, *Oxy-Acetylene Tips* has a circulation greater than the combined circulation of all other magazines in the welding field. Its volumes, totaling over 1,800 pages and containing several thousand illustrations of actual welding and cutting jobs, constitute what is undoubtedly the most authoritative source of published information on every phase of the oxy-acetylene process.

Present Aspects of MATERIALS FOR HIGH TEMPERATURE SERVICE from the Creep Design Standpoint

By J. J. Kanter and L. W. Spring

SOME of the most difficult engineering problems of to-day have to do with the applications of metals and alloys to service at extreme temperatures. The steam, oil and chemical industries now are pressing their operating temperatures so high that metallurgical ingenuity is considerably taxed to meet their demands and still keep a few paces ahead of practice. It is claimed that efficiencies and yields possible in steam power, oil refining and in numerous chemical processes, through higher operating temperatures, exceed somewhat present-day metallurgical practice.



Courtesy Foster Wheeler Corporation

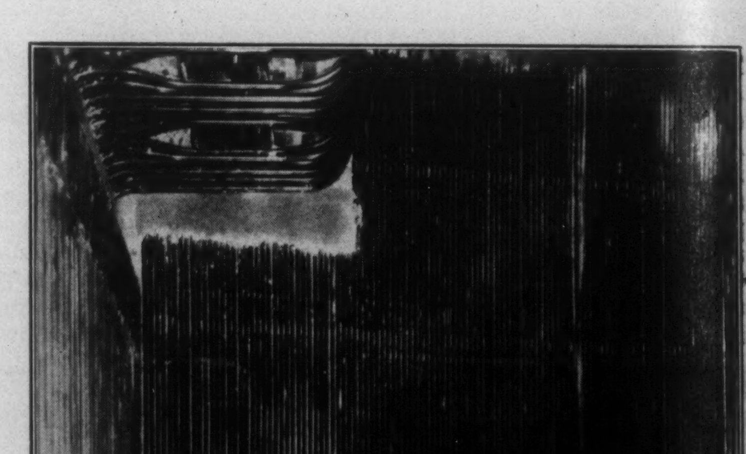
Fig. 1—The Feedwater Heater Installed in the Hell Gate Power Plant of The United Electric Light and Power Company of New York City. It Heats More Than a Million and a Half Pounds of Water per Hour at a Pressure of 500 Lbs./In.^{2}

Naturally there has been a certain amount of reluctance on the part of conservative engineers to use higher temperatures and pressures, attributable to lack of data and information concerning the long continued performance of alloys under extreme conditions. Part of this apparently was due to the engineer's thought of considerable risk in practical application of laboratory findings, and also to the heavy investment for equipment required for the new and more severe temperatures and pressures. The considerable pioneering which has been done, however, has been of inestimable value in advancing our practical knowledge of the values of various alloys for high temperature service, and few untoward results in such application, apparently, have come about.

For the purposes of the engineer, too much confidence should not be placed, alone, in the short-time tensile test as a basis of design values. In recent years it has been shown that steel is of an intrinsically different mechanical character at even mildly elevated temperatures than at atmospheric. At ordinary temperatures, steel is an excellently elastic body. So long as structures sustain only elastic deformation they are of reasonably sound design. But it is now generally recognized that at elevated temperatures the real limit of elasticity is quite low and equipment cannot be designed in a practical way upon a theory of stress strain equilibrium. Engineers have become more reconciled to the fact that creep must be accepted and dealt with at high temperatures if economic, i. e., reasonably small, metal sections are to be employed. In some applications a greater amount of deformation can be allowed than in others. The time element also must enter the calculations. Due consideration must be given the length of service which the equipment is expected to render. Corrosion and other deterioration, too, are factors in dimensioning the load carrying members and fixing stresses. Such considerations are leading to the general adoption of the long-time tensile or creep tests to supply needed information for high temperature design and selection of materials.

The interpretation of long-time tensile or creep data has been and still is a matter of some controversy. A few years ago some investigators clung to the idea of a limiting creep stress in the classical sense, i. e., a stress below which no creep takes place at elevated temperature. As mentioned, it now is the generally accepted point of view that at elevated temperatures creep is present in some degree, however small the stress—something which must be tolerated up to limits fixed by operating and other service conditions.*

For a great many purposes the prime consideration of a material's worth at high temperatures, so far as strength is concerned, is not alone how much stress it can stand without appreciable creep, but the temperature at which creep be-



Courtesy Foster Wheeler Corporation

Fig. 2—Half of a High Pressure, Round Tube Radiant Superheater Installed in the Furnace of a 2850 Hp. Bent Tube Boiler Built for an Operating Pressure of 1400 Lbs. This Superheater is Composed of Two Panels, Only One of Which is Shown Here, the Other Being in the Opposite Side Wall of the Furnace. The Superheater Raises the Temperature of 250,000 Lbs. of Steam an Hour to 750° F. The Approximate Dimensions for Each Panel Are 22 Ft. Wide and 29 Ft. High.

---

* Kanter & Spring, "Longtime" or "Flow-tests of Carbon Steels at Various Temperature with Particular Reference to Stress below the Proportional Limit." *Proceedings American Society for Testing Materials* Vol. 28 (1928) page 80.

comes apparent. The load carrying ability of the various alloys suffers considerably as we pass from a low to a high temperature. The following brief tabulation illustrates this characteristic for some materials, using as extremes, a rather high stress and a quite low one, giving from very accurate laboratory determinations of creep, the temperatures which allow these loads to produce the creep designated, viz., 1% in 10,000 hours in each case.

	Approximate Temperature Permitting Creep of		
	1% in 10,000 hrs. @ 25,000 lbs./in.^{2}	1% in 10,000 hrs. @ 1000 lbs./in.^{2}	Temperature Difference or Range
Open-hearth Iron	450° F.	1150° F.	700° F.
Low Carbon Steel (0.15 to 0.25 C)	700	1150	450
Medium Carbon Steel (0.30 to 0.40 C)	775	1050	275
Heat Treated Alloy Steel—No. 1 (0.40 C)	700	1025	325
Heat Treated Alloy Steel—No. 2 (0.40 C)	825	1150	325
Heat Treated Alloy Steel—No. 3 (6$^1/_2$Cr–6$^1/_2$W)	850	1200	350
Austenitic Nickel Chrome Steel (18Cr–8Ni)	950	1600	650
Chromel (80Ni–20Cr)	950	1550	600
Carbon Cast Steel (0.25 to 0.35 C)	700	1100	400
Nickel Chrome Cast Steel (0.40 C)	850	1125	275
	@ 15,000 lbs./in.^{2}		
Rolled Naval Bronze	325	550	225
Cast Red Brass	400	800	400
Cast Bronze	450	750	300

When Is Cost of High Alloy Steel Warranted?

Strength advantage may not necessarily warrant the added expense of some of the well-known types of high temperature alloys. Highly alloyed steels often find their place where both chemical resistance and strength (the latter not necessarily great) must be combined. If corrosion and scaling are not factors, low-priced steels often are quite satisfactory for reasonably elevated temperature service.

The popularity of 18–8 Metal is instructive in this regard. This is an alloy which has found wide use in spite of a high cost. Although it possesses excellent strength properties at quite high temperatures, such, probably, has been only a minor consideration in its fairly widespread adoption. The fact that this alloy withstands scaling, and resists oil vapor and other active kinds of corroding agents to a high degree, is the real reason for its success. Reliance apparently can be placed upon its non-corrosiveness. Other austenitic alloys are known which possess even greater strength at higher temperatures than 18–8. Most of these are more expensive and many not as chemically stable at red heats. The mere strength advantage of these has not proven an inducement to the users to buy them.

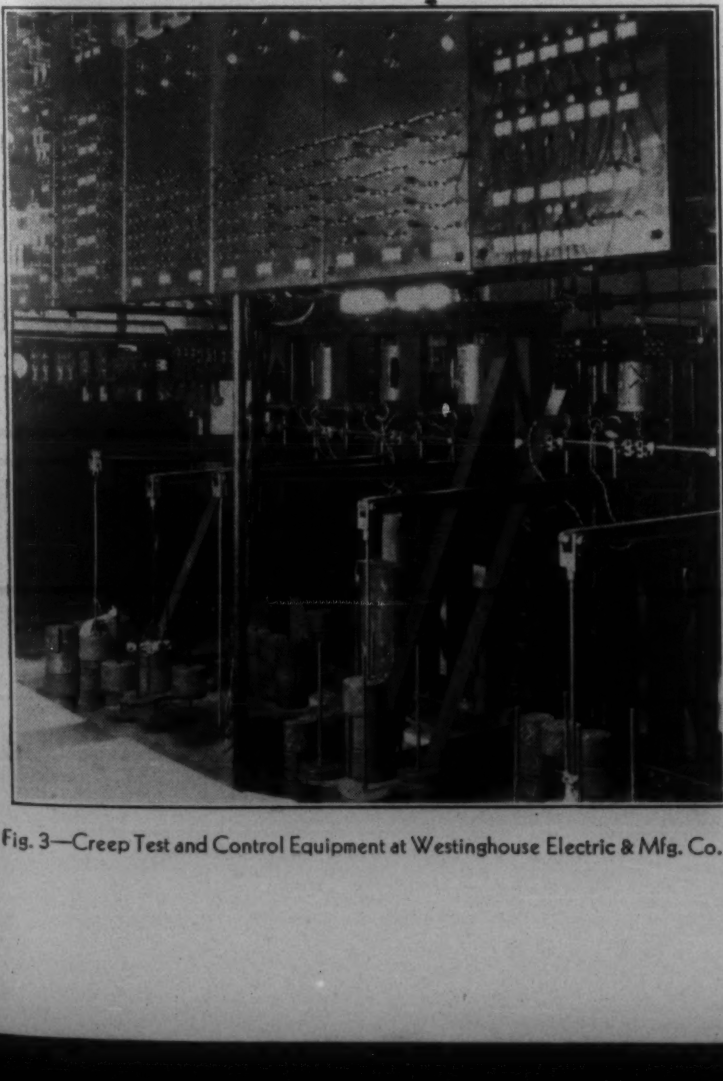


Fig. 3—Creep Test and Control Equipment at Westinghouse Electric & Mfg. Co.

It is not generally a difficult problem to build a piece of high pressure equipment for elevated temperature use which will be sufficiently strong and rigid even though the stresses to which the designer is limited are quite low. The real problem of those dealing with severe conditions seems to be whether or not the material they build into their equipment will remain intact and sound. In the oil refinery, for instance, assurance is wanted that the still tubes will not corrode down to a paper shell thickness before an inspection of the lines, can be made. Strength deficiencies usually can be compensated for by making the metal section heavy enough, but high corrodability and deterioration are the really insidious dangers in the application of metals and alloys at high temperatures.

One might ask, if the high strength in a metal at high temperature is not a prime requisite so far as pressure vessels are concerned, why pay so much attention to research on the stability of materials? The answer to this question is that accurate information is needed about that available margin of strength, in order that good use can be made of it. Thus, a great deal of effort is being made to determine to just how high temperatures the various metals and alloys may be subjected, before a comparatively small stress will produce failure through creep. The foregoing table shows, for a number of typical materials, the highest temperatures at which they will safely support 1000 lbs./in.^{2} stress with no more than 1% of creep in 10,000 hrs. This limit is seen to range from 450° F. (230° C.) for Rolled Naval Bronze to 1600° F. (870° C.) for 18–8 Metal.

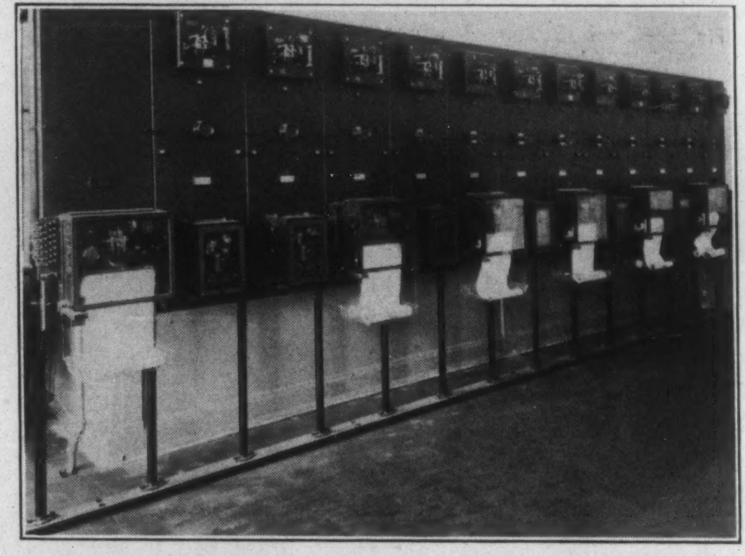


Fig. 4—Control Board for Creep Equipment at Crane Co. The Crane Co. Creep Outfit Is Illustrated on Page 449 of the April Issue of *Metals & Alloys*

The finding of a practical steel which has a long time tensile strength of 25,000 lbs./in.^{2} or more at 1000° F. (540° C.) steel is a major problem to the metallurgist serving oil refiners and power plant designers. A good bolting steel must retain a high elastic limit at elevated temperatures. Up to temperatures of 750° F. (400° C.) no real difficulty is encountered in this regard. Certain of the low alloy steels, fairly inexpensive materials, have been keeping flanges tight for the last 10 years or more in superheated steam and in oil cracking service. While some of these, according to the evidence of creep tests, should be serviceable under the temperatures at least 100° F. (55° C.) higher, that may be near their limit under tomorrow's more strenuous conditions. Even with as great alloy content as 6.5% tungsten and 6.5% chromium, the long time strength (1% in 10,000 hrs.) at 1000° F. does not exceed 12,000 lbs./in.^{2}. The steels which seem to have the highest strength and toughness at this higher temperature and above are of the highly alloyed austenitic type.

The matter of allowable fiber stresses in low carbon steel pressure vessels has come in for considerable controversy during the last few years. Attention has focused particularly upon 900° F. Through various lines of reasoning upon the results

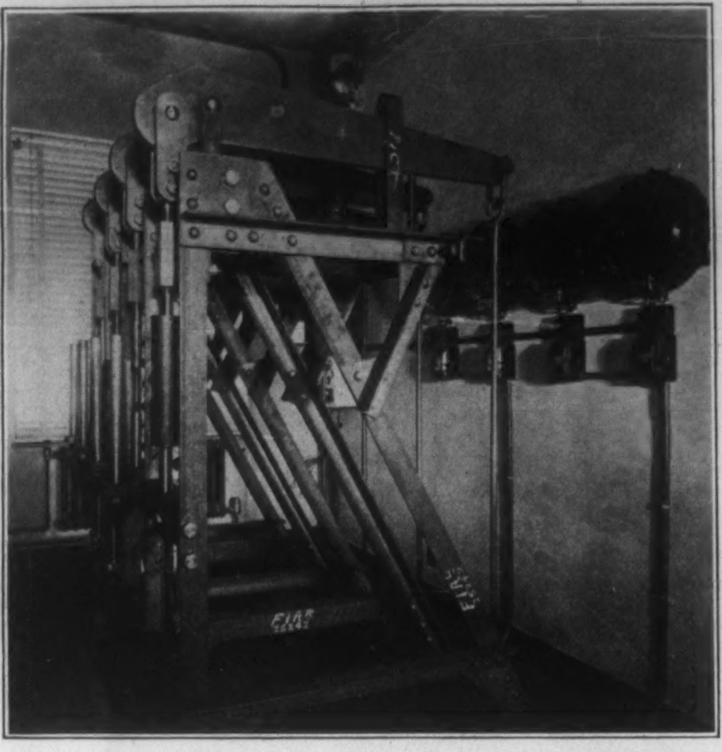


Fig. 5—Creep Outfit at Battelle Memorial Institute, Patterned after the Crane Company's Equipment

of high temperature tensile tests, several investigators have arrived at safe working loads for 900° F. Estimates of the safe fiber stress for low carbon steel plate at 900° F. vary from 5000 to 8000 lbs./in.^{2} depending somewhat upon the kind of service. The working loads in oil refinery equipment generally are placed at higher values than for superheated steam work due to quicker obsolescence, etc.

Large gaps remain in the existing information concerning the elastic constants of metals at elevated temperatures. The effects of temperature upon the elastic properties in tension, of course, are well understood. Young's modulus of elasticity has been carefully determined for numerous steels. But this apparently is not enough to satisfy the mathematical elastician. He is clamoring for data upon the effect of temperature on Poisson's ratio (ratio of lateral contraction to extension). Both of these mentioned constants will be required in order to compute accurately the strains in tubes, flanges and other objects in which the metal is subjected to combined stresses. Thus far, no method of sufficient delicacy seems to have been devised for the direct measurement of Poisson's ratio upon tensile bars at elevated temperature. Some investigators are turning to the high temperature torsion test as a method of attacking this problem. From the combined results of tension and torsional moduli, this constant may be computed. The success of such a method, however, will depend upon extremely accurate testing technique.

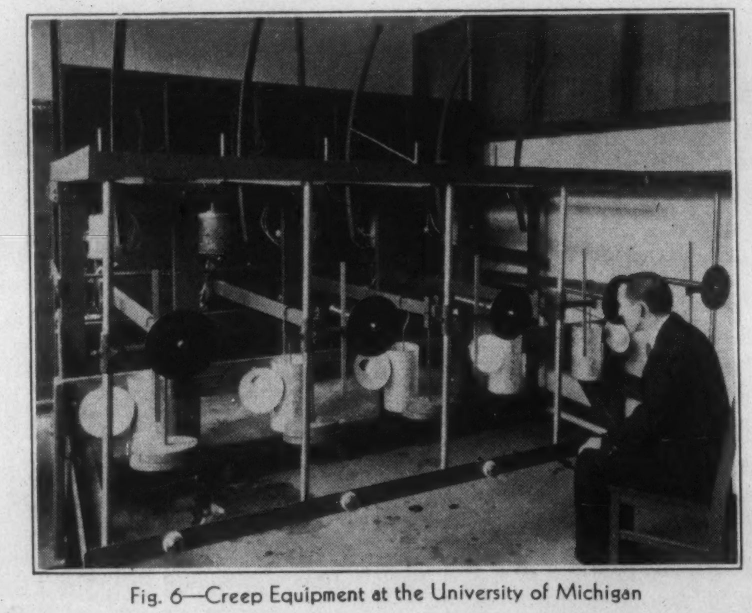


Fig. 6—Creep Equipment at the University of Michigan

Some of the highly refined developments in physical testing of metals at elevated temperatures relates very intimately to the behavior of the metals in the modern steam turbines which now are operated at temperatures upward of 850° F. In this application parts must be designed to withstand severe pulsating stresses for indefinite periods of time. It is claimed that the total amount of deformation due to creep which can be tolerated in turbine parts must not exceed 0.2% in 20 years. With such exacting limitation within which to work, the testing engineer concerned with turbine design naturally is cautious to a fault.

What has been learned bout the subject of effect of temperature on fatigue of metal also has been done largely on behalf of turbine design. It is now generally recognized that fatigue failure becomes of relatively less importance as the temperature scale is ascended, that is, at the higher temperatures creep phenomena becomes the more important factor in the behavior of metals in service. It is almost impossible to say just at what temperature we should cease to regard fatigue limit and begin paying attention to creep data. No doubt there is a range of temperature over which both factors must be considered. The available fatigue data for high temperatures indicates that before fatigue failure occurs, stresses capable of producing high rates of creep usually are required. On the other hand, low temperature fatigue failures often appear at stresses vastly lower than stresses which could give but the merest trace of plastic deformation.

Through the American Society for Testing Materials and American Society of Mechanical Engineers research committees efforts are being made to place upon a coöperative basis certain phases of the high temperature investigations on metals and alloys which industry is using. This work was started in 1924 with the organization of a joint committee for the purpose sponsored by the two societies. Since that time this committee has promoted work upon testing methods, bibliography, technical literature, service surveys and other undertakings pertaining to this field. The results of these efforts are being made available through the publications of the sponsoring societies, some of the papers being presented and discussed first at meetings of the societies. The work of this committee, as well as of other American Society for Testing Materials and American Society of Mechanical Engineers committees chartered to investigate various mechanical and metallurgical aspects of this field, is being carried forward with increasing activity. The enthusiastic interest and willingness to coöperate that many industries are showing is at least assuring that the present high temperature problems will before long have been exhaustively examined, if not satisfactorily solved.

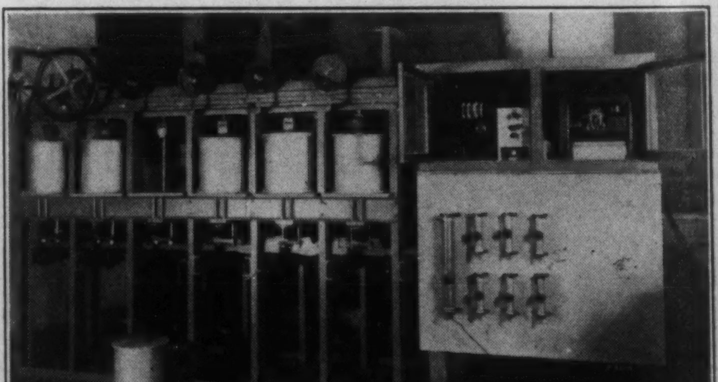


Fig. 7—Creep Equipment at the Carbide and Carbon Research Laboratory

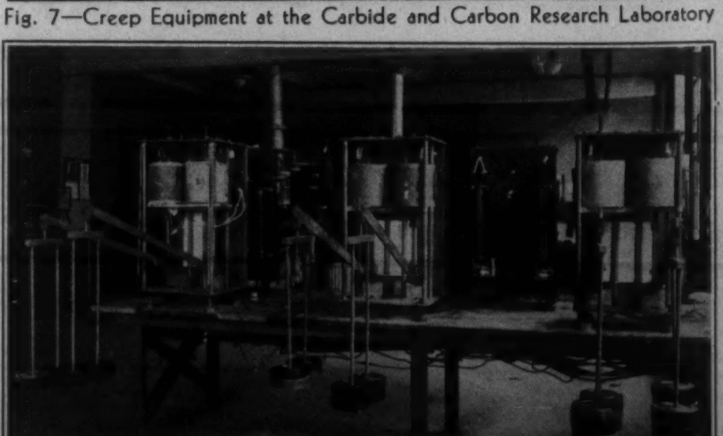


Fig. 8—Creep Outfit at the Bureau of Standards

Fundamental and Applied Research on the Physical Chemistry of STEEL-MAKING*

By C. H. Herty, Jr.†

Synopsis

The work on the physical chemistry of steel-making, as carried out at the Pittsburgh Experiment Station of the United States Bureau of Mines in coöperation with Carnegie Institute of Technology and the Metallurgical Advisory Board, has covered a series of fundamental studies on the action of oxygen in liquid steel and the application of the findings to open-hearth operation. The staff has varied from 14 to 23 men per year, some of whom have been Bureau of Mines physical chemists and metallurgists, others, research engineers of the Metallurgical Advisory Board, and the remainder graduate students employed as research fellows at the Carnegie Institute of Technology. The work on the laboratory studies, and particularly on slag systems, has been in charge of G. R. Fitterer, associate metallurgist, Bureau of Mines, while the plant work has been under the direction of C. F. Christopher, research engineer of the Metallurgical Advisory Board. In all, some 16 physical chemists and metallurgists and 24 research fellows have taken part in the experimental work. Advantage has been taken of the opportunity for coöperation with the University of Pittsburgh to have certain phases of this program made the subject of graduate work, particularly the laboratory studies on the deoxidation of steel with manganese-silicon alloys.

The general method of studying oxygen has been, first, to determine the solubility of the various oxides in liquid steel. To date, the solubility of FeO in steel has been determined over a wide temperature range.[1]

The straight-line relationship in the plot of solubility versus temperature indicated that under a slag of 100% FeO the oxygen was present in the steel as dissolved FeO. A further conclusion drawn from this work was that the solubility of FeO in the metal was proportional at a given temperature to the mol fraction of FeO in the slag if the slag contained a large excess of basic constituents. This result was determined from a st udy of the solubility of FeO under slags containing lime and iron oxide in various proportions. These data have been used extensively in determining the saturation of a bath of open-hearth steel under any conditions of slag composition, and results to be given later showed that the solubility curves are consistent with the results obtained in practice.

Second, a study was made of the equilibria and types of inclusions formed when highly oxidized steel was deoxidized with various alloys. Concurrently, the slag systems which were involved were studied by the synthesis of the slags in the induction furnace and their examination under the microscope and determination of their melting points by the micropyrometer method. Up to the present time the studies have included deoxidation with silicon;[2] deoxidation with aluminum;[3] deoxidation with manganese;[4] deoxidation with manganese-aluminum alloys;[4] deoxidation with aluminum-silicon alloys;[4] and deoxidation with manganese-silicon alloys.[4] In these studies low-carbon heats were made in a Moore 'Lectromelt furnace, and 20 to 25 lb. ladles of metal were deoxidized with the various deoxidizers mentioned. The double deoxidizers were made in the small induction furnaces of the bureau's laboratory (see Fig. 1).

Fig. 1—Induction Furnace Laboratory, Pittsburgh Station, U. S. Bureau of Mines

Deoxidation with Silicon

The equilibrium constant for the reaction

$$Si + 2FeO \rightleftharpoons SiO_2 + 2Fe$$

was found to be $K = (\text{concentration of FeO})^2 (\text{concentration of silicon}) = 1.49 \times 10^{-4}$, when both silicon and FeO are expressed as weight percent. From open-hearth data obtained after this investigation was finished, the value of 1.65×10^{-4} was found. In all this work FeO was determined by hydrogen reduction. The two findings are in excellent agreement and thermodynamic calculations have given fair checks with these two results. The types of non-metallic inclusions formed on deoxidation are (1) glassy siliceous inclusions when the steel is completely killed; (2) large ferrous-silicate inclusions when the steel is semi-killed; and (3) very large ferrous silicates high in FeO when only a small addition of silicon is made to the melt. From these results and from open-hearth work done later it was shown that deoxidation of a bath of metal with silicon alone was quite unsatisfactory in so far as cleaning the metal was concerned. The silica particles were so small that they took an excessively long time to rise out of the metal, which resulted in dirtiness of the steel in the ladle and in the ingot. This conclusion has been checked a number of times in the work of the past year.

---

* Published by permission of the Director, U. S. Bureau of Mines, Carnegie Institute of Technology, and the Metallurgical Advisory Board. (Not subject to copyright.)

† Physical chemist, metallurgical section, U. S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.

[1] C. H. Herty, Jr., J. M. Gaines, Jr., B. M. Larsen & others, The Physical Chemistry of Steel Making: The Solubility of Iron Oxide in Iron. *Coöperative Bulletin* 34, *U.S. Bureau of Mines, Carnegie Institute of Technology and Mining & Metallurgical Advisory Boards* (1927) 68 pages.

C. H. Herty, Jr. & J. M. Gaines, Jr., The Effect of Temperature on the Solubility of Iron Oxide in Iron. *Transactions Iron and Steel Division, American Institute of Mining & Metallurgical Engineers* (1928) pages 142–156.

[2] C. H. Herty, Jr. & G. R. Fitterer, The Physical Chemistry of Steel-Making: Deoxidation with Silicon and the Formation of Ferrous-Silicate Inclusions in Steel. *Coöperative Bulletin* 36, *U. S. Bureau of Mines, Carnegie Institute of Technology and Mining & Metallurgical Advisory Boards* (1928) 90 pages.

[3] C. H. Herty, Jr., G. R. Fitterer, & J. M. Byrns, The Physical Chemistry of Steel-Making: Deoxidation of Steel with Aluminum. *Coöperative Bulletin* 46, *U. S. Bureau of Mines, Carnegie Institute of Technology, and Mining & Metallurgical Advisory Boards* (1930) 43 pages.

[4] As yet unpublished.

The slag system FeO–SiO_2 has been reported in Coöperative Bulletin 36.[2] In this work the melting point of FeO was estimated at between 1355 and 1377° C., with the probability that it was nearer 1355 than 1377° C. At 22% silica a eutectic was indicated, the eutectic temperature being 1240° C. (Fig. 2). The presence of this eutectic was definitely found upon micro-analysis. The compound fayalite ($2FeO.SiO_2$) was found to melt at 1335° C. A second eutectic melting at 1260° C. was found at 35% silica. The results obtained in the study of this system thoroughly substantiated the work done on the identification of ferrous-silicate inclusions resulting from the deoxidation of steel with silicon.

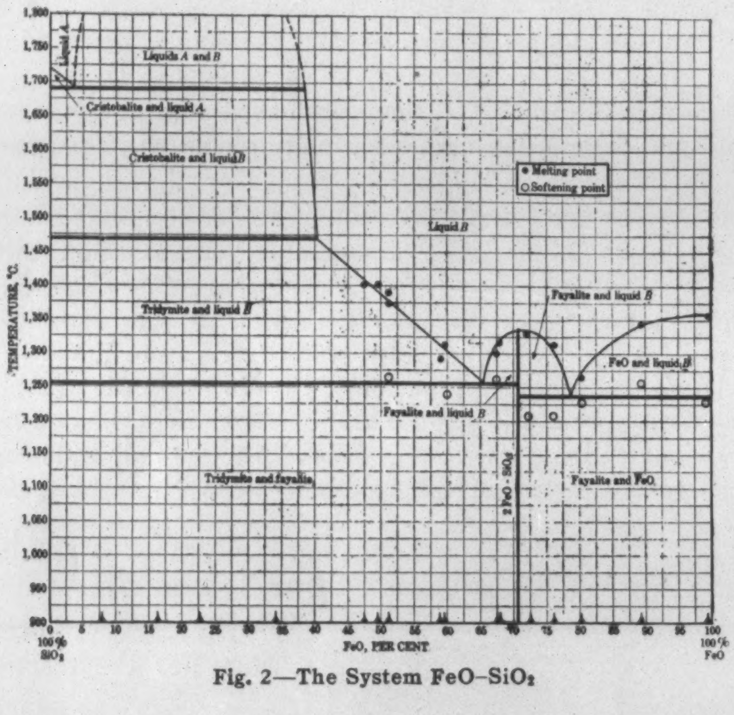


Fig. 2—The System FeO–SiO_2

Deoxidation with Aluminum

The work on deoxidation with aluminum gave a deoxidation constant of $K = Al^2 \times FeO^3 = 5.7 \times 10^{-7}$ and indicated that the aluminum reaction was only slightly stronger than the silicon reaction but, as indicated later, the reaction with aluminum is much more rapid than the reaction with silicon. The types of inclusions formed were the very fine alumina particle, so well known to steel-makers, when the steel was dead-killed and some fluxing of FeO with alumina when the steel was partly killed. In neither case was sufficient fluxing found to evidence a rapid cleaning of the metal when treated with aluminum.

The system Al_2O_3–FeO was studied as described, but it was found that only a small portion of range was fusible at steel-making temperatures. The results (Fig. 3) indicated an unstable compound at 74% Al_2O_3 and a eutectic at 57% Al_2O_3, the eutectic having a melting point of 1490° C. In this system the zone of slags fusible at steel-making temperatures was very small and explains the lack of coalescence of inclusions in steel deoxidized with aluminum.

Deoxidation with Manganese

The work on deoxidation with manganese presented an extremely difficult problem, as it was very desirable to know the amount of manganese oxide present in the metal. For this reason the work on manganese was delayed for some time until a satisfactory method had been obtained for this purpose. At the present time the electrolytic method, described later, is being used to determine the amount of MnO in steel and experimental work on the solubility of MnO in liquid steel is now in progress. The deoxidation constant has not been determined in the laboratory, as have the deoxidation constants for silicon and aluminum, because with manganese, unless in very large amounts, the steel was never dead-killed and segregation in the small ingots was so pronounced that it was impossible to obtain good values for the reaction $Mn + FeO = MnO + Fe$. However, thermodynamic calculations have been made to show the value of this constant and are in fair agreement with the experimental data that have been obtained. This phase of the work is to be continued during this coming year (1930–1931), and it is believed that with the electrolytic method for determining MnO developed to its present state of accuracy, it will be much simpler to determine this constant than has been heretofore estimated. In general, the MnO inclusions found in steel could be grouped into two classes: (1) Where the steel was heavily deoxidized with manganese, definite crystalline inclusions were found, a great many of them showing a dendritic structure and some of them being diamond shaped. The different shapes of these inclusions can be explained by a study of the micro-polishing planes which could intercept the dendritic or crystalline inclusions of the cubic system. (2) As less manganese is added to the steel, typical globules are encountered, some of which showed immiscibility or at least two phases and others of which were single-phase globules.

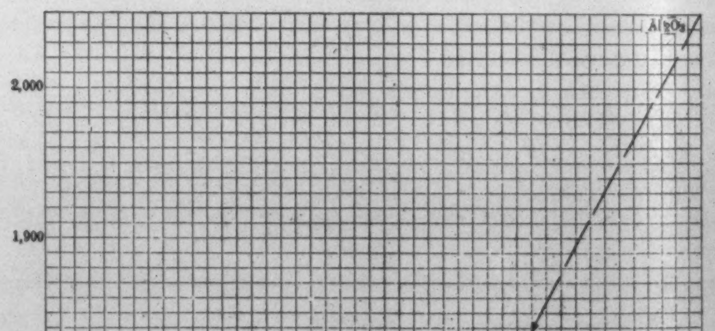


Fig. 3—Melting Points of FeO–Al_2O_3 Slags

The system MnO–FeO has been determined to be a continuous series of solid solutions. Fig. 4 gives the experimental results. These are indicative of the difficulty of eliminating manganese oxide from liquid steel. During the coming year it is hoped to make viscosity determinations in part of this system.

Deoxidation with Manganese-Aluminum Alloys

In deoxidation with manganese-aluminum alloys, the deoxidation constant for aluminum was calculated and gave a value of 5.1×10^{-7}. This was considered an excellent check on the deoxidation constant when aluminum alone was used as a deoxidizer. The inclusions resulting from the deoxidation of manganese-aluminum alloys were almost all small inclusions corresponding somewhat to the inclusions found on deoxidation with aluminum alone. Although some of the slags in the system $MnO–Al_2O_3$ are quite fusible at steel-making temperatures, it is probable that reaction of aluminum with iron oxide is so much more rapid than that of manganese with iron oxide that the predominant inclusion is aluminum with only a small amount of manganese oxide present. This type of inclusion was formed regardless of the composition of the alloys used for deoxidation, except when the ratios of manganese to aluminum were so high that they would have little practical application to steel-making processes.

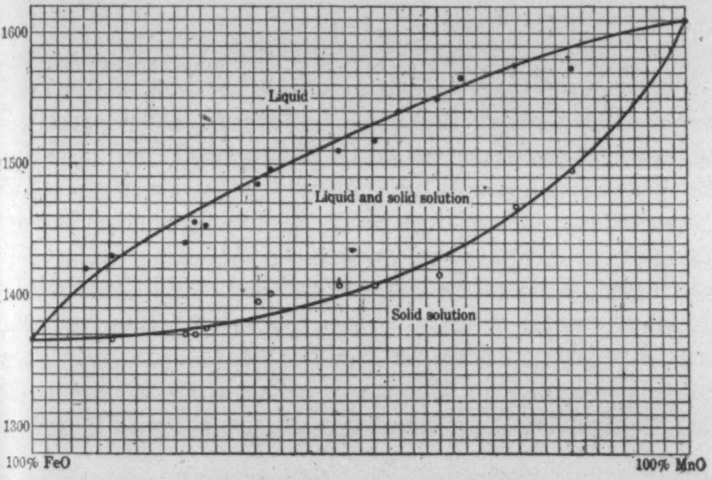


Fig. 4—FeO–MnO Equilibrium Diagram

In the work on deoxidation with manganese-aluminum alloys only a few synthetic slags were melted, and as the results on deoxidation showed that there was little chance of forming fusible inclusions in this system by this method of deoxidation, the work on the slag system was suspended and the equilibrium diagram was not determined, although it will probably be taken up later as part of the complete work in the four-component system $FeO–MnO–SiO_2–Al_2O_3$.

Deoxidation with Aluminum-Silicon Alloys

In the work on deoxidation with aluminum-silicon alloys, it was not thought necessary to study the extent of deoxidation in the same way as had been done with aluminum and silicon, inasmuch as the deoxidation constant should obviously be the same for the individual deoxidizers, regardless of the way they were introduced into the steel. It was found that in steels dead-killed with aluminum-silicon alloys, a type of particle slightly different from alumina was obtained. The inclusions had coalesced slightly and grouping was very pronounced. Furthermore, segregation in the ingots from this series was greater than with any other deoxidizer studied. Over a wide range of composition of aluminum and silicon in the alloys this type of inclusion was found, and the high segregation was explained by the fact that the particle was large enough not to act colloidally, as alumina does, but was small enough to escape through the dendrites which formed on solidification, these two factors giving a high segregation in the top of the aluminum-silicon killed ingots. The analyses of these inclusions are extremely interesting. Unless very high silicon and low aluminum contents were used in the deoxidizing alloy, the inclusions analyzed from 75 to 95% Al_2O_3 and from 5 to 25% silica. With very small amounts of aluminum in the deoxidizing alloys the silica content of the inclusions increased, and the type of inclusion approached that formed on deoxidation with silicon alone. Similarly, with low-silicon content in the deoxidizing alloy, the type of inclusion approached that formed when aluminum alone was used. The fact that the deoxidation constants given above were approximately the same for both aluminum and silicon, but the inclusions formed on deoxidation with the double alloy were so much higher in alumina, indicated that the aluminum-iron oxide reaction was very much faster than the silicon-iron oxide reaction. When the steel was semi-killed or rimmed with aluminum-silicon alloys, larger inclusions were formed and this phase of the problem is under investigation at the present time.

The alumina-silica diagram is shown in Fig. 5. The range of fusibility of these slags is extremely small, and the results obtained on deoxidation with aluminum-silicon alloys are those which would be expected from consideration of this diagram. Preliminary experimental work on the system $SiO_2–Al_2O_3–FeO$ has shown that fluid slags exist over a considerable range of composition, explaining the coalescence of inclusions in the steels semi-killed or rimmed with the Al-Si alloys.

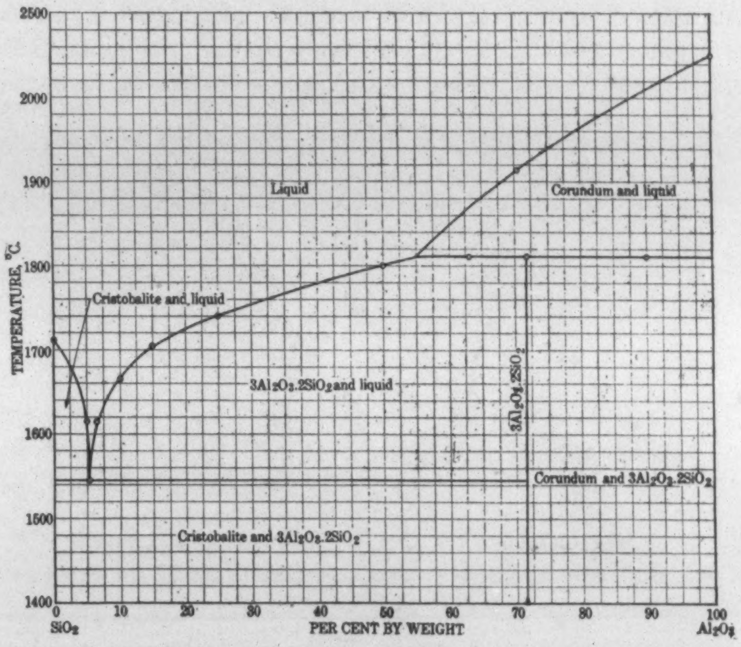


Fig. 5—The System $SiO_2–Al_2O_3$. (After Bowen & Grieg, *Journal American Ceramic Society*, Vol. 7 (1924) page 242.)

Deoxidation with Manganese-Silicon Alloys

The work on manganese-silicon alloys consisted of deoxidation of low-carbon steel with various manganese-silicon alloys. In this work some remarkable results were obtained as far as inclusion size is concerned. The non-metallic content of the steels produced was first determined by the inclusion-count method and from 0.15 to 0.25% of inclusions was found in the steel. Micro-examination of the inclusions indicated that particles were formed which were several thousand times larger than any ever found before. The ingots were next submitted for electrolytic extraction and determination of the non-metallic content and it was at once observed that some particles as large as 1/4 inch in diameter were present in the samples. The percentage of inclusions as determined by the electrolytic method varied from 0.10 to 0.30 throughout the series, and the average of the entire group was close to 0.20%. The average by the inclusion-count method was about 0.18%, the two methods being in good agreement on individual ingots except where extreme segregation occurred. The ratio of MnO to SiO_2 was increased as the ratio of manganese to silicon in the deoxidizer increased, but not as much. Furthermore, large inclusions extracted from various ingots gave analyses which were quite different from the average of the entire ingot. The analyses of two ingots and of single large particles (see Fig. 6) from these ingots were as follows:

Ingot No.	MnO	Percent SiO_2	FeO	Ratio MnO/SiO_2
1511	0.110	0.107	...	1.03
Large inclusion from 1511	59.4	34.4	6.2	1.73
1527	0.150	0.140	...	1.07
Large inclusion from 1527	55.4	35.5	9.1	1.56

From these results it was evident that the smaller particles must have been higher in SiO_2 than in MnO, and there must have been some preferential deoxidation and coalescence. Under the conditions of deoxidation there were some small particles which were high in silica and would hardly be expected to coalesce rapidly. This phenomenon is now under investigation. The results showed further that the range of composition of the alloys which gave extremely large particles was, in ratios of manganese to silicon, from 4 : 1 to about 10 : 1. From an operating standpoint this was decidedly encouraging, because a wide range in this work meant more latitude in composition of alloys for use in large furnaces. After these results had been obtained a study was begun on methods of sizing the extracted inclusions and freeing them from contamination with carbon and ferrous hydroxide. The results as applied to this problem showed that if inclusions from a single ingot were separated into four sizes, the largest particles were dark in color and the smallest were light, and the latter contained a large number of particles which appeared to be nearly pure silica. The analyses of the sizes of inclusions from two samples of ingot No. 1525 are given in the table following:

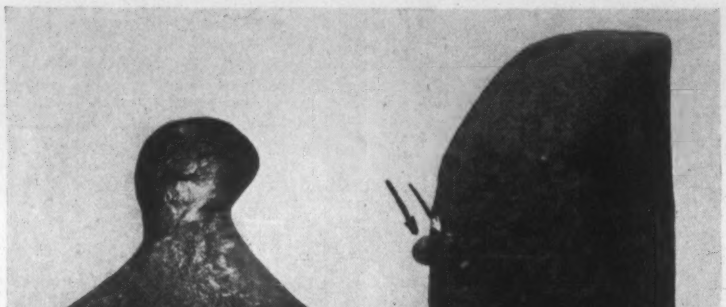

Magnification 8 × Magnification 2 ×

Fig. 6—Large Manganese–Silicate Inclusions Partly Extracted by the Electrolytic Method

Size	Percent* MnO	Percent* SiO_2	Ratio MnO/SiO_2	Percent of particles extracted
No. 1				
On 200 mesh	49.0	51.0	0.96	39
Through 200 mesh	44.5	55.5	0.80	61
No. 2				
On 200 mesh	47.5	52.5	0.90	31
Through 200 mesh	42.7	57.3	0.74	69

* Corrected to 100% to eliminate contamination by carbon and ferric hydroxide.

These results are in excellent agreement with those reported above, the smaller particles being higher in silica than the intermediate sizes (on 200 mesh). Two interesting points will be noted from this table: First, the silica content in the small particles approaches the amount at which acid open-hearth slags become very viscous. Second, the minus 200-mesh particles constitute the largest percentage of total oxides. This method of attack would seem to be an ideal way to work out the problem of utility of deoxidizers. Work on this problem is being continued.

The binary system $MnO–SiO_2$ is shown in Fig. 7. A great deal of experimental work has been done during the last year and a half on the system $FeO–MnO–SiO_2$. It has been found that there is a very fusible range of slags lying between planes bounded by 22 and 33% silica, and on either side of this range the slags gradually grow more viscous until at 85% MnO and 55% SiO_2 the slags become quite viscous. It is, therefore, of the utmost importance to obtain inclusions which fall in the fluid range if very large particles are desired. As will be noted from the discussion on deoxidation, the largest particles found in the steel samples fell in or near this very fluid range in the ternary diagram. The remainder of the ternary diagram has been studied from the standpoint of melting points and will be published in the near future.

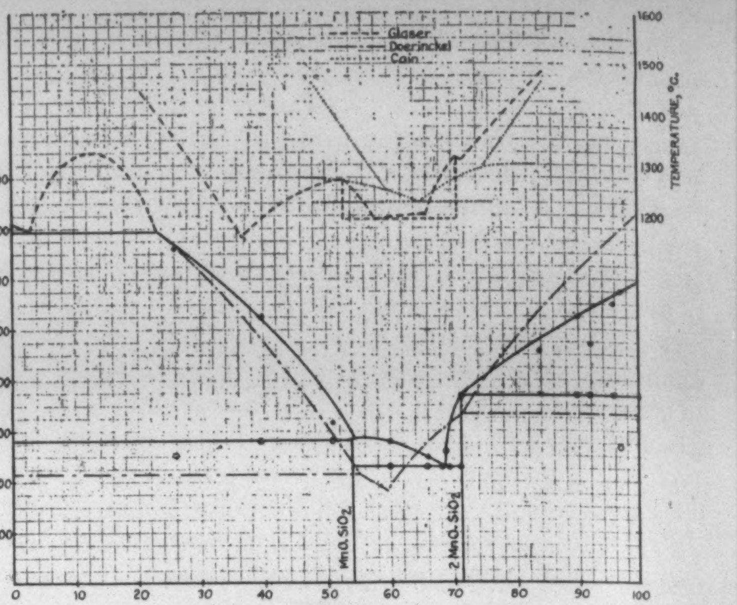


Fig. 7—Binary Systems $MnO–SiO_2$

Slag Viscosity

The study of slag viscosity constitutes the third phase of the work. The method being used to study slag viscosity is the torsion viscosimeter method similar to that used by Feild and Royster in their measurements on the viscosity of blast-furnace slags except that an induction furnace is being used instead of a carbon-resistor furnace. More accurate temperature measurements have been made by the use of the ardometer instead of an optical pyrometer. The furnace construction (Fig. 8) is quite similar to that used by McCaffery at the University of Wisconsin in his work on blast-furnace slags. To date, determinations of viscosity have been completed in that portion of the lime–silica system which is fluid at steel-making temperatures. The results show that the point of minimum viscosity is at the compound $CaO·SiO_2$ and on either side of the compound the viscosity increases quite rapidly. The eutectics in this system had no apparent

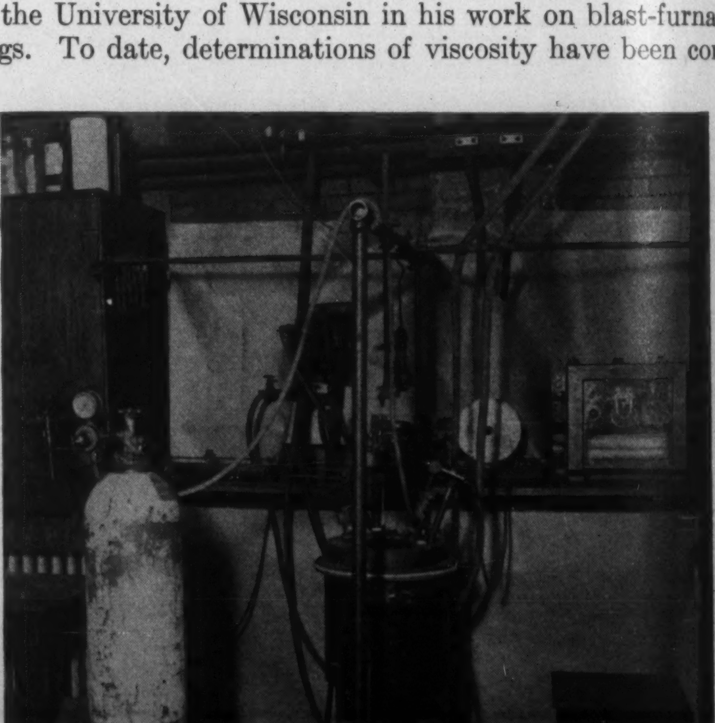


Fig. 8—Viscosimeter for High Temperature Work

effect on the slope of the viscosity curve. This result is in contradiction to work of previous investigators, but sufficient points were collected to state definitely that for the lime-silica system the viscosity is not a minimum at the eutectic point, but rather at the compound point. Future work with the apparatus is to be directed toward determinations of the viscosities of oxidizing slags and of some of the slags in the systems FeO–MnO–SiO_2 and FeO–MnO. Coöperative Bulletin 47,[5] was issued in October 1930, on viscosity determinations in the lime–silica system.

Equilibrium between Carbon and Iron Oxide

One of the most interesting investigations has been on the determination of the equilibrium between carbon and iron oxide in liquid steel and on the oxidation of the metal in the open-hearth furnace. Up to the past year, all FeO determinations had been made by the hydrogen-reduction method. This method is felt to be quite satisfactory on steels when no gas evolution takes place on solidification, but when gas is evolved, as in all steel samples taken from an open-hearth furnace, unless the steel is deoxidized a considerable evolution of gas takes place with a considerable loss in oxygen. With this in mind a method of determining FeO by adding aluminum wire to a spoonful of liquid steel was devised. The alumina formed is determined by chemical analysis and calculated to be the equivalent FeO in the metal. By this method a great number of open-hearth heats have been studied, and the general conclusions are that as the carbon decreases, the iron oxide content of the metal increases quite rapidly. When the carbon is extremely low or when the temperature is extremely low, the iron oxide content of the metal is controlled by the iron-oxide content of the slag and the temperature. For intermediate carbons and for high temperatures the FeO content of the metal is determined by the rate of the carbon-iron oxide reaction and by the rate of diffusion of iron oxide from slag to metal. A typical heat is shown in Fig. 9. From the results obtained it has been possible to calculate the apparent equilibrium constant for the reaction $C + FeO \leftrightarrows CO + Fe$ in the open-hearth furnace. The rate at which carbon is eliminated may be expressed by the equation

$$\frac{-dC}{d\Theta} = k(C)(FeO) - k'(CO).$$

This may be rewritten

$$\frac{-dC}{d\Theta} = k[(C)(FeO) - (C)(FeO) \text{ at equilibrium}].$$

Thus by plotting the rate of carbon elimination against the product (C)(FeO) we should obtain a line which would intercept the (C)(FeO) axis at the equilibrium value when the rate of carbon elimination is zero. This equation has been tested with excellent results on a large number of open-hearth heats. The experimental points, rate of carbon elimination and (C)(FeO) in the metal when plotted against each other give a straight line which intercepts the (C)(FeO) axis at approximately 0.010 for the product (C)(FeO). At temperatures above 1600° C. the product is slightly less and at lower temperatures the product is slightly greater, indicating the trend of the equilibrium constant with temperature. The high-temperature points are somewhat in doubt as it has been found that the calculation of temperatures is not trustworthy if the temperature is higher than the melting point of manganese oxide—1600° C. From the same data, rate constants for the rate of carbon elimination have been determined, and rates of diffusion of FeO from slag to metal have also been determined. In general, the rate constants for the rate of carbon elimination from heat to heat varied with the temperature and with the agitation of the bath. However, these rate constants are surprisingly uniform not only for a given heat but also from heat to heat, thus confirming not only the method of determining iron oxide in the steel but also the apparent equilibrium constant given above. Rates of diffusion as calculated from the equation

$$\frac{dFeO}{d\Theta} = KA(\Delta FeO),$$

where ΔFeO = FeO saturated − FeO actual, were found to vary tremendously with the agitation of the bath. With a lively action on the bath the rate constants were of the magnitude of 5.0 lbs. FeO/min./ft.^{2} of slag-metal area/% ΔFeO, whereas with a dead-killed bath the rate constants were about 0.10, expressed in the same units. The diffusion constants were also affected by slag viscosity, as would be expected from operating observations and theoretical considerations. Further work is being done on this to fill in certain gaps in the experimental data.

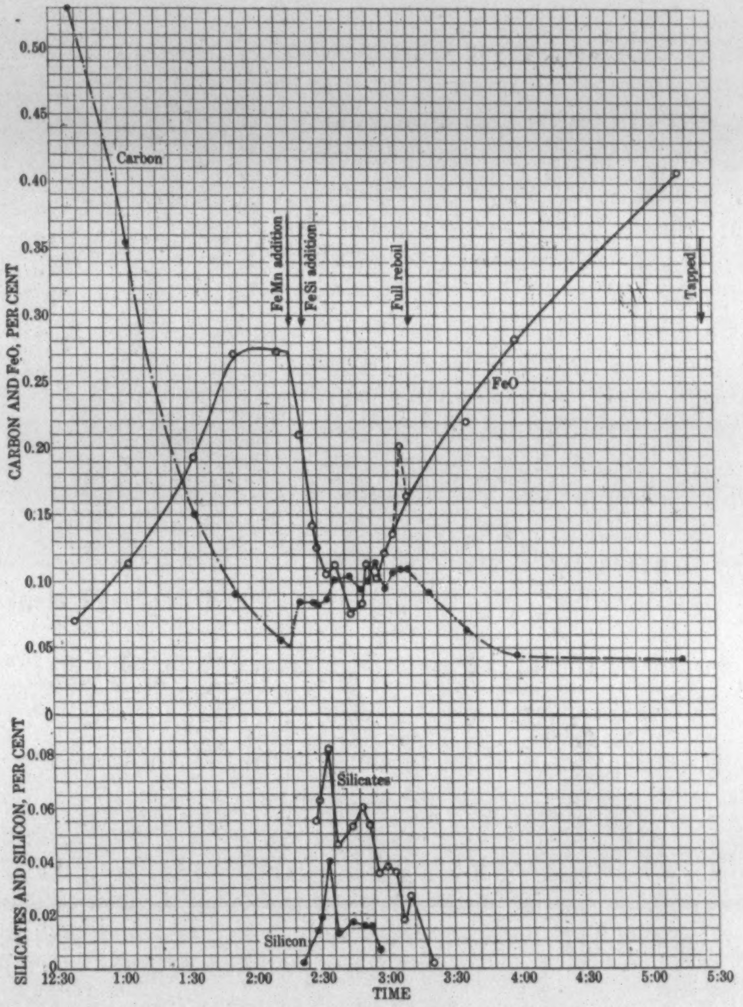


Fig. 9—Iron Oxide Content of Open-Hearth Steel as Determined by Deoxidation with Aluminum

Effect of Inclusions on Rolling Steel

The research work on the effect of inclusions on the rolling, surface and physical properties of finished steel has been slowed up somewhat during the past year because all the plant research men are working on the deoxidation stage of open-hearth refining.

During the past year a great number of physical tests have been made on clean and dirty steels from the various heats made in this investigation. The results in general have shown (1) that the impact value falls off with increasing non-metallic content; (2) that the ultimate strength, yield point, elongation and reduction could not be correlated with variations in total non-metallic content, and that dirty steel gave more irregular results than clean steel on fatigue testing, although the dirty steels did not necessarily have lower fatigue values than the clean steels. These results lead to the thought that segregation and type of inclusion are probably more

---

[5] C. H. Herty, Jr. F. A. Hartgen & others, Temperature-Viscosity Relations in the Lime–Silica System. *Coöperative Bulletin* 47, *U. S. Bureau of Mines, Carnegie Institute of Technology, and Mining & Metallurgical Advisory Boards* (1930) 27 pages.

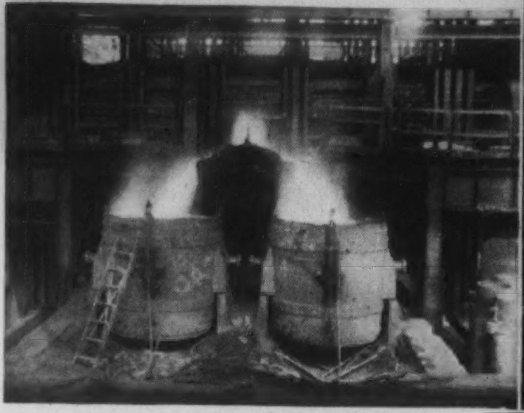


Fig. 10—Tapping a 75-ton Open-Hearth at the Edgewater Steel Company

Fig. 11—Tapping a 250-Ton Open-Hearth at the Jones & Laughlin Steel Corporation

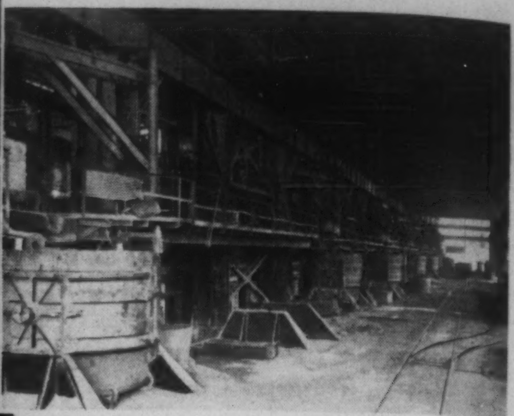


Fig. 12—Open-Hearth Plant, Pittsburgh Steel Company

important than total non-metallic content. As soon as the problem on deoxidation with manganese and silicon in the open hearth is completed, this phase of the work will be resumed.

Careful inspection of ingots on all the test heats of this investigation leads to the conclusion that ingot surface is one of the most important factors in determining chipping costs of the grade of steel studied. The control of ingot surface by control of mold conditions, temperature of teeming, other pouring conditions and deoxidation of the metal is under investigation at the present time.

Fig. 13—Taking a Melter's Test at the Heppenstall Company

Deoxidation of Steel in the Open-Hearth Furnace

The first deoxidizer studied in open-hearth practice was silicon. The results of this study have been published in Coöperative Bulletin 38 and dealt with deoxidation of low and medium carbon steels with silicon. The results showed that when silicon alone was used as a deoxidizer, silica and silicate particles inevitably resulted in the finished product and that it was extremely difficult to get a fair cleaning of the bath before a reboil commenced. It was found in this work that the larger the particle the more rapid the cleaning of the bath, as would be expected from Stokes' law, and various other factors affecting deoxidation and oxidation of open-hearth steel were discussed.

The work on deoxidation with manganese and silicon and manganese-silicon alloys in the basic open-hearth furnace has been the center of attention of the plant research men on the staff for the past year.

Twenty-five heats have been made during the past year using manganese (as ferro or spiegel) and silicon pig, special silicon-manganese alloys, and high-silicon spiegel for deoxidation. The special alloys were supplied through the courtesy of the Heppenstall Forge and Knife Co. and the high-silicon spiegel through the New Jersey Zinc Sales Co. Of these heats the first 15 were completely reboiled and then made into either rimmed or killed steel, and the remainder were tapped while still dead.

The elimination of non-metallic matter was hastened by using manganese (either as ferro or spiegel) ahead of the silicon. When using the silicon-manganese alloy and the high-silicon spiegel the elimination was speeded up still further. These results were obtained on heats which were fully reboiled. At this point it was felt that enough data had been accumulated to outline a practice for making low and medium carbon killed steels with the use of manganese and silicon as alloys which would produce a cleaner steel than could be obtained by the use of silicon alone. Accordingly, a number of heats were made where the bath was killed with silicon-manganese alloys and high-silicon spiegel, and the heats were tapped while the bath was still dead. Two very interesting conclusions were drawn from the first few heats studied:

1. Although the heats were fairly clean at the time the metal was tapped, the addition of silicon in the ladle resulted in the formation of silicate inclusions which were found in the pouring tests and ingots. The analysis of the steel in the furnace showed that inclusions present contained a good deal more manganese oxide than silica, whereas the steel in the ladle after the addition of ferro-silicon in the ladle contained more silica than manganese oxide. This point leads to the conclusion that either deoxidation must be more complete in the furnace or silicon must not be used in the ladle if the cleanest steel is desired. In making low-carbon killed steels with high-silicon spiegel it is impossible to use as much of the alloy as desired on account of the carbon content. It was, therefore, decided to kill two heats in the furnace with as much high-silicon spiegel as could be put in without going above specifications for carbon and to complete the deoxidation in the mold with aluminum. The heats so treated showed a low aluminum consumption in the molds, the amount used being about 1.5 oz./ton of steel. The finished steel showed a very low chipping cost and extremely low rejections due to surface defects, and was also as clean low-carbon steel as has been observed in our laboratories. This procedure is being followed on other heats of steel.

2. It was found that the addition of a small amount of ferro-manganese in the furnace after the heat had been killed with the silicon-manganese alloys was very effective in cleaning up residual oxides in the metal. Accordingly, our present furnace practice in making low-carbon killed steel is to add the high-silicon spiegel, to allow the bath to lie dead for 8 to 12 minutes, add ferro-manganese to meet specifications, and then tap the heat 10 to 15 minutes after the ferro-manganese addition. At present, comparison is being made between steels treated with ferro-silicon in the ladle and with aluminum in the molds. These developments have opened up a new subject for research—namely, the possibility of using a double deoxidizer in the ladle rather than straight ferro-silicon, as addition of the latter to the ladle inevitably results in silicate inclusions in the ingot.

It is interesting to note that during the past year, 25 heats have been studied completely, whereas it required some $2^1/_2$

years to complete the investigation of 12 heats of steel treated with silicon. This increase in the number of heats studied per year is due primarily to the three improvements in methods of analysis—namely, the determination of FeO in liquid steel by deoxidation with aluminum, and the determination of non-metallic content of steel by the inclusion-count method and by the electrolytic method.

The plant work has been conducted at the Jones & Laughlin Steel Corporation's South Side Works, the Pittsburgh Steel Co., Monessen, Pa. and the Edgewater Steel Co., Oakmont, Pa.

Research on Acid Open-Hearth Steel

In coöperation with the Heppenstall Co. of Pittsburgh, Pa., research has been in progress for the last eight months on oxidation and deoxidation of acid open-hearth steel. The aluminum method for determining FeO in liquid steel has been used throughout this work, as have the inclusion-count and electrolytic methods for determining inclusions in steel.

Some of the striking results of this investigation are: (1) Although the steel may be cleaned considerably by good action on the bath (a rapid rate of carbon elimination) during the early stages of the heat, there is apparently a critical point at which contamination from bottom material commences. By the proper use of spiegel for reboiling, this contaminating matter is very largely eliminated. (2) The use of double deoxidizers of manganese and silicon has improved the cleanliness of the steel considerably compared to the use of ferro-manganese and ferro-silicon. The finished product is more uniform in physical properties after deoxidation with the double alloy.

Although the work has not progressed sufficiently to make any extensive calculations, preliminary calculations based on the amount of FeO dissolved in the steel and on the diffusion coefficients given previously have enabled us to calculate the mineral composition of the acid slag. On the three heats studied the dissociation of ferrous silicate in the slag has been calculated, and the results on all three heats are in fair agreement. This work is to be continued, and once the dissociation constants are determined satisfactorily it will be possible to predict the rate of oxidation of the bath from the slag analysis and the carbon content of the metal. The important part which slag viscosity plays in the cleaning of the heat after deoxidation has also been demonstrated.

Analytical Methods Developed

During the course of the investigation a thorough study has been made of the Dickenson method for determining non-metallic inclusions in steel and its shortcomings have been pointed out in Coöperative Bulletin 37.[6]

In view of the unreliability of the hydrogen reduction method for determining FeO in liquid steel, a new method has been devised in which the liquid steel is killed with aluminum and the Al_2O_3 determined by chemical analysis. The oxygen and Al_2O_3 are calculated to equivalent FeO and the results are expressed as such.[7] This method has been used during the past year on all heats studied.

Another method of interest in determining inclusions in steel is the inclusion count which is described in Coöperative Bulletin 38.[8] This method involves a counting of the number of particles in a piece of cast or rolled steel and a calculation of the relative areas of inclusions and steel. From the densities of the two materials it is possible to calculate the percentage of non-metallic matter in the steel.

One of the most important factors in the entire work has been the development of the electrolytic method for the determination of non-metallic inclusions in steel. This method consists in electrolyzing a solid sample of steel in a solution of ferrous sulphate and sodium chloride, the strength of the solution being 3% ferrous sulphate and 1% sodium chloride in water for killed steels, and 2% ferrous sulphate and 0.5% sodium chloride for rimmed steels or any steels where manganese oxide predominates. The sample is sawed to a size about 1 inch square by 4 inches in length, drilled in the top and soldered to a platinum wire, and acts as the anode in the cell. The sample is suspended in a collodion bag made from a solution of collodion in alcohol and ether; the bag is filled with the ferrous sulphate solution and then immersed in the main ferrous sulphate solution which is contained in a copper tank. The current used is about 1 amp. per sample and the amount of iron dissolved is approximately 1 g./hr.; 24 to 36 g. of steel is dissolved, the bag is then removed from the tank, washed carefully and the steel sample and contents of the bag are washed into a beaker. The inclusions are then analyzed for MnO and SiO_2. If alumina is desired on the sample it is general practice to determine alumina directly rather than to attempt to separate the alumina from the iron which is present in the inclusions as contamination from the electrolysis. The residues from the electrolysis may be dried and screened so that the inclusions are separated into different sizes suitable for micro-examination or for analysis. This method has also been used on rolled steels and some remarkable results have been obtained in the separation of the inclusions so that the stringers of silicate may be examined under the microscope. This method was used in the work on the study of deoxidation with manganese and silicon alloys, as noted in the foregoing text.

At a special stockholders' meeting held in the company's offices November 1st, the name of the American Metal Products Company was changed to Ampco Metal Inc., and the capital stock of the company was increased from $400,000.00 to $500,000.00. Ultimately the company will be capitalized at $1,000,000.00, the additional capital to be used in plant extension for the production of Ampco Metal in sheet, rod, wire, forgings, etc.

The American Metal Products Company was organized in 1914 and the trade name "Ampco" is derived from the initials of the company name. Since, however, Ampco Metal has become nationally known and used, it is deemed advisable to change the company name to the more descriptive name indicated.

Calendar of Meetings

American Institute of Chemical Engineers, New Orleans, La., Dec. 8–10, 1930.

Association for the Advancement of Science, Cleveland, Ohio, Dec. 29, 1930–Jan. 3, 1931.

American Institute of Electrical Engineers, Annual Winter Convention, New York, N. Y., Jan. 26–30, 1931.

American Society of Mechanical Engineers, Fourth National Fuels Meeting, Chicago, Ill., Feb. 10–24, 1931.

Fifth Midwest Power Engineering Conference.

Midwestern Power and Engineering Exposition.

Second Western Metal Congress, Auditorium, San Francisco, under auspices of American Society for Steel Treating, Feb. 16–20, 1931.

American Chemical Society, 81st Meeting, Indianapolis, Ind., Mar. 30–Apr. 3, 1931.

American Electrochemical Society, Hotel Tutwiler, Birmingham, Ala., Apr. 23–25, 1931.

Thirteenth Exposition of Chemical Industries, Grand Central Palace, New York, N. Y., week of May 4th, 1931.

American Foundrymen's Association, Stevens Hotel, Chicago, Ill., week of May 4th, 1931.

---

[6] C. H. Herty, Jr., G. R. Fitterer & J. F. Eckel, The Physical Chemistry of Steel Making: A Study of the Dickenson Method for the Determination of Non-Metallic Inclusions in Steel. *Coöperative Bulletin* 37, *U. S. Bureau of Mines, Carnegie Institute of Technology and Mining & Metallurgical Advisory Boards* (1928) 25 pages.

[7] C. H. Herty, Jr., J. M. Gaines, Jr. & Others, A New Method for Determining Iron Oxide in Liquid Steel. *Technical Publication* 311, *American Institute Mining & Metallurgical Engineers* (1930) 13 pages.

[8] C. H. Herty, Jr., C. F. Christopher & R. W. Stewart, The Physical Chemistry of Steel-Making: Deoxidation with Silicon in the Basic Open-Hearth Process. *Coöperative Bulletin* 38, *U. S. Bureau of Mines, Carnegie Institute of Technology, and Mining & Metallurgical Advisory Boards* (1930) 172 pages.

The Influence of a Small Addition of Copper on the Corrosion Resistance of Structural Steel*

By O. Bauer, O. Vogel and C. Holthaus

Condensed by V. V. Kendall

The development of any alloy for resisting corrosion is always of interest, particularly if the quantity of the alloying element is sufficiently small as to make no appreciable difference in the cost of production. This is the case with the addition of copper to commercial forms of steel. The value of copper steel for resistance to atmospheric corrosion is fairly well established in this country. It is generally considered, however, that for under-water service no marked advantage is gained from the presence of copper. There is still much that remains to be clarified and the work of the German investigators is a valuable addition to our data on the subject.

In 1927 the Prussian Minister for Commerce and Industry initiated a series of small scale laboratory and large scale tests using three variations of carbon and six variations of copper content. The large scale tests which consist of sheet piles of the various materials will continue for six years and will be reported on at that time. The preparation of the necessary materials was undertaken by the Vereinigte Stahlwerke A.-G. Dortmunder Union in Dortmund. The small scale tests were carried out, part at the Staatlichen Materialprüfungsamt and part at the Dortmunder Union, most of them at both places.

The tests were outlined as follows:

I Complete chemical analysis:
  (a) Analysis of the kinds of steel (see Table 1)
  (b) Analysis of the waters used (see Table 2)
II Determination of the physical properties (see Table 1)
III Metallographic examination
IV Corrosion experiments at room temperature (see Table 3)
  (a) In distilled water
  (b) In river water
  (c) In North Sea water
  (d) In water containing humic acids
  (e)[1] Alternate wet and dry experiments in 1% sodium chloride
  (f)[1] Alternate wet and dry experiments in distilled water
  (g)[1] In the atmosphere (on the roof of the Materialprüfungsamt at Dahlem)
  (h) In 1% sulphuric acid
  (i)[1] In 1% hydrochloric acid
V Corrosion experiments at +50° C. (122° F.) (see Table 3)
  (a) In distilled water
  (b) In river water
  (c) In North Sea water
  (d) In water containing humic acids
  (e)[2] In 1% sulphuric aicd
VI[2] Corrosion experiments with sheet specimens with roll scale (See Table 4)
  (a) In tap water
  (b) In North Sea water
  (c) In 0.5% hydrochloric acid
  (d) In saturated steam.

The materials consisted of soft steel (0.08% C), structural steel (0.15–0.25% C) and 0.25–0.35% C steel each containing 0.0, 0.1–0.15, 0.25–0.35, 0.5, 0.75 and 1.0% copper. These were in the form of sheets about 5 mm. (0.197″) thick and, after the scale was removed, were polished.

Table 2 Analysis of Water

Appearance	River Water (Spree Water) Clear Yellow, Odorless, with Small Brown Flocculent Sediment	North Sea Water Colorless, Odorless, without Sediment	Water Containing Humic Acid Turbid, Brown, Slight Hydrogen Sulphide Odor with Brown Flocculent Sediment
Analysis—parts per million:			
Silicic acid	11	Trace	19
Lime	65	274	63
Magnesia	8	2288	28
Bicarbonate	49	30	45
Sulphuric acid (SO_3)	19	2119	75
Chlorine	28	18,510	172
Nitric acid	None	None	Trace
Hydrogen sulphide	None	None	Trace
Organic material	103	None	171
Total residue dried at 125° C. (255° F.)	257	36,594	602
Hardness in German degrees (1 degree 1 part by weight of calcium or the equivalent amount of magnesia in 100,000 parts of water)			
Total hardness	7.6	347.7	10.2
Permanent hardness	1.4	343.9	4.5
Temporary hardness	6.2	3.8	5.7

Physical Properties.—The variation in carbon content, particularly of the 0.25–0.35% C steel as also the high manganese content of soft steel specimen G-1 caused some variation in the results. However the general trend is for an increase in yield point and elastic limit and a decrease in elongation and reduction in area from 0.18% Cu up to 1.0% Cu.

Metallographic Examination.—The metallographic examination of all eighteen materials showed no influence of copper up to 1% on the structure.

Table 4

		% loss in weight			
Material	Copper	Tap Water 15 Months	North Sea Water 15 Months	0.5% Hydrochloric Acid 30 Days	Saturated Steam 15 Months
W 1	0.04	34.6	52	52	84
W 2	0.15	31.4	37	38	81
W 3	0.35	29.2	31	33	72
W 4	1.09	26.8	28	29	64

Table 1. Chemical analyses and Physical Properties of Steels
Made in the Laboratory of the Dortmunder Union

Kind of Steel	Mark	% C	% Si	% Mn	% P	% S	% Cu	Elastic Limit lbs./in.²	Ultimate Strength lbs./in.²	Elongation %	Reduction of Area %
Soft Steel	G 1	0.13	Trace	1.00	0.074	0.044	0.04	61,100	76,700	27.8	59
	A 1	0.09	Trace	0.49	0.041	0.040	0.18	47,600	59,700	32	62.8
	B 1	0.07	Trace	0.53	0.061	0.042	0.27	48,300	65,400	31.8	62.5
	C 1	0.07	Trace	0.53	0.068	0.044	0.61	51,200	66,200	29.3	61.0
	D 1	0.07	Trace	0.51	0.058	0.042	0.80	55,500	69,100	27.5	55.0
	E 1	0.08	Trace	0.64	0.061	0.040	1.04	64,000	79,000	28.0	58.0
Structural Steel	G 2	0.15	Trace	0.51	0.048	0.035	0.04	64,000	86,200	26.2	52.0
	A 2	0.15	Trace	0.50	0.061	0.040	0.15	51,800	68,200	26.7	58.0
	B 2	0.25	Trace	0.76	0.085	0.044	0.30	60,000	78,100	23.4	50.0
	C 2	0.22	Trace	0.54	0.047	0.040	0.58	54,000	72,500	26.6	50.0
	D 2	0.19	Trace	0.54	0.064	0.040	0.84	57,800	76,000	28.0	57.3
	E 2	0.22	Trace	0.81	0.064	0.036	1.07	64,000	85,500	23.4	51.7
0.25 to 0.35 C Steel	G 3	0.27	Trace	0.73	0.051	0.034	0.03	59,700	87,100	22.3	49
	A 3	0.29	Trace	0.73	0.059	0.028	0.18	59,100	84,600	20.0	43.4
	B 3	0.29	Trace	0.78	0.035	0.032	0.37	57,000	81,300	24.6	50.3
	C 3	0.29	Trace	0.90	0.090	0.034	0.54	60,800	91,700	22.7	48.0
	D 3	0.32	Trace	0.80	0.065	0.044	0.72	65,300	89,500	20.0	45.0
	E 3	0.24	Trace	0.67	0.088	0.040	1.05	67,700	86,000	29.2	48.3

---

* Original appeared in *Mitteilungen der deutschen Materialprüfungsanstalten*, Sonderheft XI (1930) 25 pages.

[1] Experiments run at the Staatlichen Materialprüfungsamt only.

[2] Experiments run at the Dortmunder Union only.

Table 3

	Material			Soft Steel						Structural Steel						0.25–0.35 C Steel					
	Sample			G 1	A 1	B 1	C 1	D 1	E 1	G 2	A 2	B 2	C 2	D 2	E 2	G 3	A 3	B 3	C 3	D 3	E 3
	Chemical Analysis % Cu			0.04	0.18	0.27	0.61	0.80	1.04	0.04	0.15	0.30	0.58	0.84	1.07	0.03	0.18	0.37	0.54	0.72	1.05
	Chemical Analysis % C			0.13	0.09	0.07	0.07	0.07	0.08	0.15	0.15	0.25	0.22	0.19	0.22	0.27	0.29	0.29	0.29	0.32	0.24
			Days							% Loss in Weight											
Tests Made at Room Temperature	In Distilled Water	Staatlichen Materialprüfungsamt	20	0.203	0.192	0.192	0.175	0.168	0.161	0.199	0.198	0.187	0.177	0.154	0.147	0.205	0.180	0.187	0.187	0.201	0.159
			40	0.367	0.360	0.364	0.311	0.312	0.298	0.377	0.380	0.355	0.314	0.294	0.290	0.387	0.320	0.352	0.343	0.351	0.297
			60	0.520	0.499	0.514	0.450	0.456	0.452	0.536	0.549	0.506	0.461	0.438	0.447	0.566	0.494	0.472	0.497	0.501	0.450
		Dortmunder Union	20	0.199	0.187	0.202	0.195	0.181	0.169	0.190	0.190	0.190	0.187	0.187	0.184	0.227	0.174	0.195	0.223	0.187	0.209
			40	0.354	0.352	0.369	0.356	0.345	0.350	0.405	0.362	0.312	0.336	0.347	0.350	0.391	0.345	0.381	0.388	0.383	0.354
			60	0.510	0.590	0.520	0.500	0.476	0.510	0.530	0.510	0.453	0.487	0.500	0.500	0.690	0.530	0.610	0.630	0.610	0.583
	In River Water (Spree River)	Staatlichen Materialprüfungsamt	20	0.204	0.192	0.197	0.190	0.192	0.195	0.201	0.195	0.190	0.175	0.181	0.172	0.191	0.167	0.169	0.168	0.199	0.172
			40	0.396	0.402	0.402	0.390	0.383	0.386	0.416	0.397	0.378	0.350	0.357	0.360	0.372	0.347	0.348	0.368	0.401	0.360
			60	0.588	0.570	0.583	0.575	0.556	0.566	0.616	0.596	0.576	0.546	0.547	0.551	0.538	0.540	0.539	0.582	0.555	0.556
		Dortmunder Union	20	0.183	0.155	0.173	0.160	0.162	0.150	0.185	0.190	0.183	0.177	0.176	0.174	0.165	0.154	0.164	0.160	0.147	0.143
			40	0.307	0.408	0.421	0.414	0.337	0.288	0.306	0.305	0.297	0.307	0.281	0.308	0.315	0.328	0.323	0.280	0.300	0.282
			60	0.600	0.500	0.520	0.500	0.550	0.570	0.570	0.570	0.570	0.570	0.570	0.560	0.660	0.560	0.540	0.530	0.610	0.530
	In Sea Water (North Sea)	Staatlichen Materialprüfungsamt	20	0.140	0.129	0.128	0.131	0.128	0.129	0.142	0.139	0.133	0.136	0.133	0.139	0.148	0.135	0.142	0.138	0.141	0.139
			40	0.254	0.258	0.250	0.253	0.246	0.249	0.270	0.254	0.243	0.254	0.257	0.261	0.274	0.262	0.264	0.253	0.253	0.267
			60	0.364	0.359	0.361	0.349	0.344	0.367	0.394	0.376	0.348	0.377	0.358	0.371	0.383	0.371	0.388	0.354	0.365	0.366
		Dortmunder Union	20	0.225	0.235	0.220	0.240	0.210	0.205	0.235	0.224	0.222	0.220	0.220	0.210	0.215	0.220	0.230	0.228	0.224	0.220
			40	0.366	0.375	0.359	0.355	0.314	0.365	0.385	0.356	0.347	0.369	0.377	0.343	0.381	0.380	0.410	0.372	0.361	0.365
			60	0.492	0.510	0.510	0.510	0.472	0.500	0.523	0.486	0.508	0.499	0.477	0.468	0.532	0.492	0.567	0.524	0.509	0.502
	In Humic Acid Water	Staatlichen Materialprüfungsamt	20	0.040	0.020	0.016	0.014	0.013	0.016	0.033	0.024	0.024	0.016	0.018	0.013	0.022	0.015	0.016	0.020	0.015	0.019
			40	0.130	0.063	0.049	0.055	0.032	0.035	0.078	0.079	0.048	0.066	0.035	0.026	0.083	0.048	0.050	0.043	0.054	0.033
			60	0.249	0.111	0.160	0.111	0.070	0.106	0.233	0.235	0.128	0.109	0.101	0.091	0.101	0.071	0.049	0.123	0.055	0.046
		Dortmunder Union	20	0.165	0.200	0.191	0.168	0.168	0.159	0.145	0.118	0.127	0.120	0.135	0.139	9.142	0.125	0.131	0.155	0.150	0.140
			40	0.409	0.380	0.351	0.379	0.374	0.381	0.452	0.385	0.403	0.404	0.421	0.425	0.459	0.400	0.421	0.395	0.419	0.405
			60	0.567	0.519	0.579	0.567	0.564	0.534	0.602	0.573	0.597	0.577	0.553	0.585	0.581	0.554	0.562	0.517	0.589	0.543
	Alternating Wet and Dry in*	1% Sodium Chloride Solution	30	1.746	1.572	1.574	1.603	1.576	1.721	1.710	1.752	1.850	1.789	1.851	1.939	1.775	1.850	1.850	1.899	1.867	1.933
			60	5.591	5.458	5.639	5.815	5.982	6.411	5.538	5.865	6.475	6.143	6.643	5.931	5.725	6.063	6.696	6.991	6.229	6.532
			75	8.189	7.997	8.608	8.920	8.825	8.634	8.321	8.831	8.923	8.950	9.487	7.860	8.755	8.255	8.961	8.645	8.343	8.340
		Distilled Water	30	0.301	0.228	0.235	0.222	0.199	0.204	0.232	0.225	0.194	0.189	0.192	0.199	0.235	0.177	0.177	0.161	0.198	0.194
			60	0.602	0.452	0.423	0.380	0.394	0.378	0.442	0.389	0.385	0.408	0.384	0.366	0.462	0.360	0.396	0.320	0.336	0.347
			75	0.640	0.484	0.465	0.483	0.469	0.503	0.588	0.491	0.455	0.532	0.454	0.428	0.572	0.442	0.488	0.414	0.396	0.431
			Mos.																		
	In the Atmosphere*		3	0.849	0.727	0.728	0.677	0.646	0.627	0.723	0.669	0.621	0.685	0.670	0.611	0.704	0.604	0.638	0.613	0.625	0.633
			6	1.128	0.975	1.014	1.015	0.996	0.972	1.107	1.047	0.962	0.961	0.947	0.894	1.108	0.922	1.012	0.929	0.972	1.009
			9	1.624	1.522	1.473	1.543	1.522	1.521	1.623	1.573	1.391	1.570	1.565	1.413	1.574	1.366	1.445	1.290	1.299	1.283
			Days																		
	In 1% Sulphuric Acid*	Staatlichen Materialprüfungsamt	1	2.032	0.320	0.321	0.257	0.220	0.226	1.525	0.619	0.507	0.185	0.192	0.321	2.128	0.259	0.235	2.167	0.259	0.481
			2	4.134	0.601	0.637	0.509	0.441	0.431	3.158	1.280	1.130	0.320	0.403	0.477	4.197	0.571	0.475	4.891	0.593	0.942
			3	5.464	0.921	1.016	0.708	0.609	0.655	4.608	1.842	1.832	0.480	0.633	0.721	5.511	0.903	0.723	5.775	0.969	4.926
		Dortmunder Union	2	15.7	1.57	1.75	1.32	1.09	0.99	17.7	3.60	3.38	1.11	1.32	3.33	15.9	1.92	1.21	11.6	1.88	4.42
			5[1]	48.48	14.55	8.97	6.80	4.84	4.80	42.95	23.92	17.72	4.59	5.33	5.74	45.48	15.53	7.9	41.8	8.35	6.03
			10	92.7	15.51	13.14	10.65	9.42	11.79	91.6	30.72	29.73	8.12	12.15	11.62	87.3	24.17	11.84	65.05	15.32	11.21
	In 1% Hydrochloric Acid		1	2.356	0.346	0.349	0.322	0.294	0.311	1.684	0.531	0.459	0.243	0.290	0.275	2.039	0.321	0.293	0.251	0.353	0.304
			2	4.867	0.700	0.695	0.628	0.614	0.640	3.205	1.173	1.054	0.498	0.632	0.545	4.433	0.654	0.578	0.447	0.794	0.560
			3	7.199	0.887	1.037	0.946	0.873	0.923	5.323	1.710	1.722	0.835	0.911	0.809	6.148	0.908	0.854	0.657	1.204	0.915
Tests Made at +50° C. (122° F.)	In Distilled Water	Staatlichen Materialprüfungsamt	30	0.529	0.492	0.511	0.485	0.487	0.478	0.481	0.518	0.472	0.504	0.482	0.481	0.526	0.497	0.460	0.494	0.488	0.445
			60	1.085	1.051	1.003	1.022	0.968	0.978	1.099	1.017	0.970	1.005	1.008	1.005	1.008	0.997	0.982	0.952	1.031	0.896
		Dortmunder Union	20	1.63	0.725	1.14	1.16	0.917	1.37	1.63	0.904	1.63	1.34	0.763	1.31	0.942	0.657	0.802	0.844	0.942	0.932
			40	2.59	1.887	1.768	1.63	2.19	2.40	2.36	2.30	2.65	2.17	2.06	2.65	3.26	2.56	2.53	1.94	2.91	2.87
			60	3.73	3.07	3.29	2.65	3.76	3.60	3.90	3.78	3.98	3.93	3.55	3.83	4.78	4.64	4.33	3.60	5.50	5.50
	In River Water (Spree River)	Staatlichen Materialprüfungsamt	30	0.551	0.516	0.574	0.537	0.546	0.552	0.595	0.581	0.594	0.598	0.571	0.557	0.564	0.553	0.539	0.567	0.576	0.582
			60	1.050	1.055	1.034	1.070	1.046	0.990	1.103	1.104	1.175	1.054	1.094	1.070	1.103	1.034	1.036	1.048	1.100	1.034
		Dortmunder Union	20	0.750	0.611	0.681	0.568	0.726	0.581	0.594	0.707	0.610	0.467	0.662	0.585	0.576	0.576	0.634	0.576	0.652	0.615
			40	1.16	1.11	1.21	1.11	0.80	0.69	1.21	1.14	1.12	1.03	1.11	0.93	0.98	0.814	1.15	1.19	1.12	1.03
			60	3.33	1.93	2.56	1.89	2.80	2.51	3.87	2.08	2.90	2.48	3.16	2.95	3.52	2.82	3.39	2.67	4.40	3.22
	In Sea Water (North Sea)	Staatlichen Materialprüfungsamt	30	0.522	0.551	0.576	0.565	0.583	0.569	0.571	0.570	0.550	0.559	0.560	0.547	0.586	0.561	0.558	0.552	0.562	0.566
			60	1.063	1.014	1.102	1.068	1.108	1.097	1.104	1.036	1.035	1.030	1.055	1.084	1.174	1.100	1.070	1.056	1.046	1.107
		Dortmunder Union	20	0.476	0.494	0.571	0.509	0.480	0.451	0.456	0.567	0.523	0.572	0.523	0.519	0.460	0.441	0.479	0.479	0.436	0.456
			40	0.979	0.942	0.934	0.969	0.983	0.936	0.954	0.950	0.955	0.986	0.959	0.932	0.943	0.924	0.923	0.938	0.917	0.919
			60	1.520	1.540	1.560	1.480	1.470	1.470	1.590	1.548	1.554	1.509	1.581	1.492	1.543	1.443	1.443	1.441	1.377	1.418
	In Humic Acid Water	Staatlichen Materialprüfungsamt	30	0.502	0.449	0.361	0.364	0.356	0.383	0.420	0.458	0.318	0.361	0.341	0.446	0.565	0.418	0.410	0.398	0.474	0.471
			60	1.064	1.023	1.035	0.997	0.993	1.015	0.992	0.946	0.917	0.899	0.918	1.018	1.143	0.991	0.958	1.028	0.956	1.014
		Dortmunder Union	20	0.380	0.409	0.427	0.428	0.410	0.444	0.435	0.418	0.431	0.434	0.427	0.433	0.421	0.399	0.419	0.417	0.409	0.409
			40	0.762	0.746	0.735	0.721	0.756	0.671	0.679	0.767	0.658	0.647	0.652	0.637	0.738	0.719	0.713	0.576	0.701	0.637
			60	0.779	0.761	0.766	0.746	0.678	0.704	0.692	0.825	0.714	0.661	0.708	0.701	0.758	0.747	0.728	0.703	0.708	0.727
	In 1% Sulphuric Acid	Dortmunder Union	2	54.70	14.88	13.03	10.55	10.58	7.19	41.43	20.12	17.13	8.67	8.19	14.10	38.29	17.23	6.10	62.43	7.55	17.57
			5	95.0	35.0	29.6	26.8	24.0	18.8	79.3	42.4	38.4	21.7	21.5	38.5	56.8	38.6	17.1	93.8	17.2	37.8

Notes: All results represent the mean of 3 tests. * These tests only made at the Staatlichen Materialprüfungsamt. [1] Acid renewed after 5 days.

Corrosion Experiments at Room Temperature.—In all the experiments the specimens measured 44 × 28 × 4.5 mm. (1.73 × 1.10 × 0.177 inches) and were cleaned with benzol and with an alcohol-ether mixture, dried at 100° C. and then weighed. They were then hung in glass cylinders with 500 cc. of experimental solution, the upper edge of the specimens being 25 mm. (1 in.) below the surface of the solution. The evaporated water was replaced every ten days by the addition of distilled water. After 20, 40 and 60 days or the period of the experiment the three specimens of each material were removed. The rust was removed with a soft brush, the coating cleaned off,[3] the specimen immersed in alcohol, dried with a cloth, warmed at 100° C. and after cooling again weighed. Since all the specimens had nearly the same surface area and the same weight, they were reported in percent loss in weight. Each value reported is the mean of three individual specimens. All of the experiments except where indicated were carried out both at the Materialprüfungsamt and at the Dortmunder Union. It was found that the different room temperature existing at the two laboratories as well as the different time of year in which the experiments were run must be taken into consideration. In spite of this there is astonishingly good correlation in the results at the two laboratories.

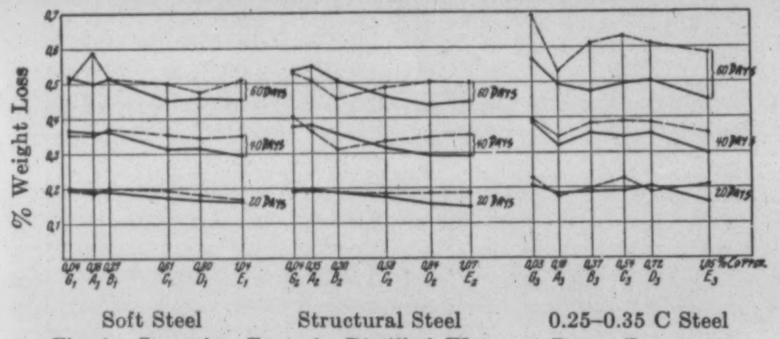


Fig. 1—Corrosion Tests in Distilled Water at Room Temperature (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

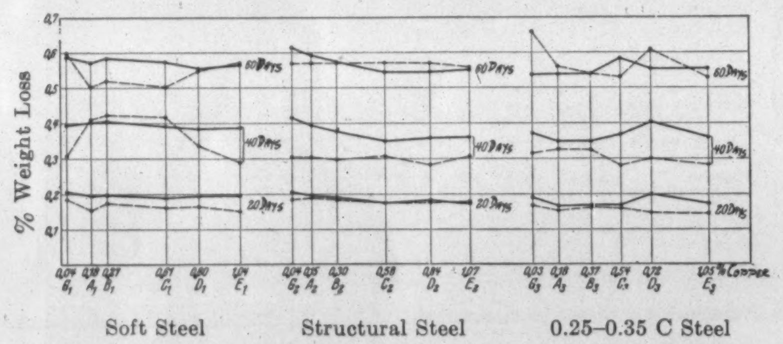


Fig. 2—Corrosion Tests in Spree River Water at Room Temperature (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

(*a*) *In distilled water* (Fig. 1). In all curves a slight decrease of corrosion was observed with increase of copper. The 0.25–0.35% C steel was somewhat more corroded than the other kinds of steel. Considerable variations were found only in the 60-day tests on this steel.

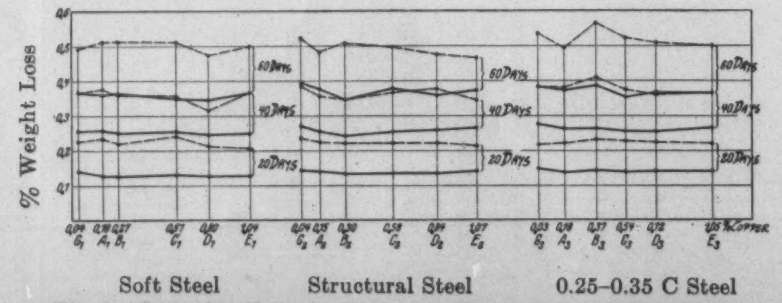


Fig. 3—Corrosion Tests in North Sea Water at Room Temperature (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

(*b*) *In river water* (Fig. 2). Results were conflicting. Considerable variations were observed in the 40- and 60-day tests at the Dortmunder Union. The final conclusions of the authors were that a definite decrease of corrosion with increasing copper content was only observed with the structural steel, that both of the other kinds of steel showed so much variation that a definite influence of copper could not be observed and that the three kinds of steel showed no marked difference in their behavior.

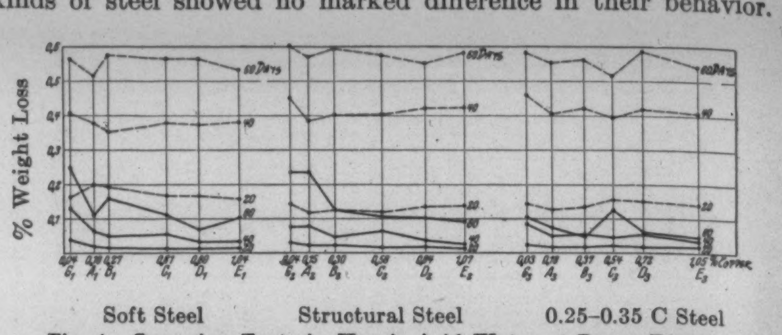


Fig. 4—Corrosion Tests in Humic Acid Water at Room Temperature (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

(*c*) *In North Sea water* (Fig. 3). The importance of maintaining the same room temperature when carrying out laboratory experiments at different laboratories is emphasized in this series. The results from the Dortmunder Union were considerably and consistently higher than those at the Materialprüfungsamt. The former were carried out in the warm summer months of 1928, the latter in the cold winter months of 1928–1929 when, during the nights, the room temperature would cool to about 8° C.

No definite influence of copper was observed in this series. The three kinds of steel behaved similarly.

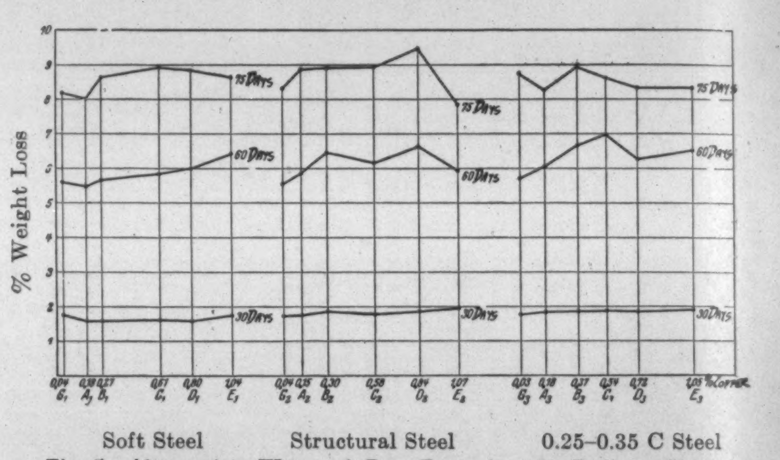


Fig. 5—Alternating Wet and Dry Tests in 1% Sodium Chloride Solution at Room Temperature (Staatlichen Materialsprüfungsamt)

(*d*) *In water containing humic acids* (Fig. 4). This water was prepared by leeching peat with tap water for three months. The experiment carried out at Dortmund showed a considerably greater loss in weight than those carried out at the Materialprüfungsamt. This was due partly to the different time of the year at which the experiments were carried out and partly to the fact that the water was renewed after every ten days. Moreover such water deteriorates with time and the water used at the Materialprüfungsamt stood about five months before use and was not renewed. The authors give their conclusions as follows: (1) With increasing copper there is a definite decrease in corrosion especially with soft steel and structural steel. (2) The 0.25–0.35% C steel showed somewhat less tendency to corrode than the soft steel and the structural steel.

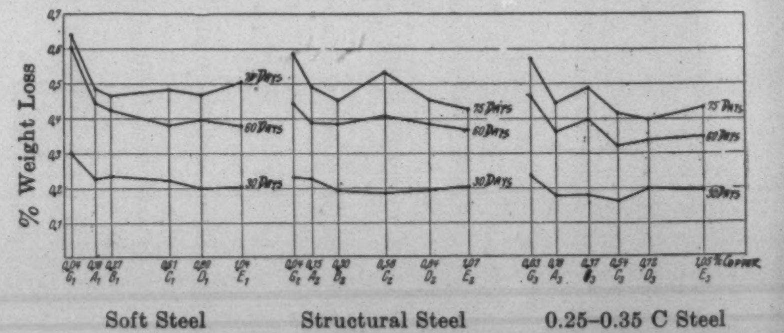


Fig. 6—Alternating Wet and Dry Tests in Distilled Water at Room Temperature (Staatlichen Materialsprüfungsamt)

(*e*) *Alternate wet and dry tests with 1% sodium chloride* (Fig. 5).

(*f*) *Alternate wet and dry tests with distilled water* (Fig. 6).

These experiments were run for 30, 60 and 75 days. The specimens were hung on glass rods in flasks with 500 cc. of the experimental solution in which they remained for 24 hours, the cycle being repeated for the period of the experiment.

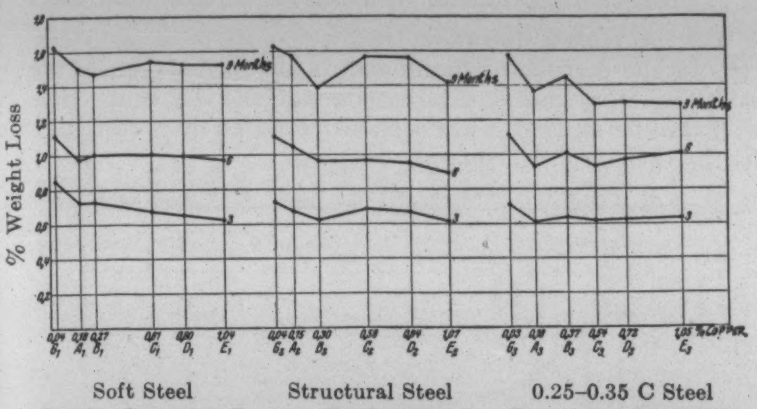
---

[3] Two methods were used for removing the rust from the small sheets.

(1) The specimens were treated with a slightly ammoniacal solution of ammonium citrate (173 g. ammonium citrate to one liter of water and 200 cc. ammonia sp. gr. 0.925). The rust is dissolved, the iron beneath is not attacked. This method was used at the Dortmunder Union.

(2) The small sheets were warmed on the water bath in 7% sodium hydroxide with zinc turnings or zinc granules. After a short time strong hydrogen evolution and reduction of the iron rust to black iron occurred. An average treatment of the rusted sheets extended for the most part to the complete reduction of the iron rust, the loose iron slime was easily washed away. With a longer treatment with sodium hydroxide and zinc a coating of zinc hydroxide remained on the sheets which was easily dissolved with sulphuric acid containing arsenious acid (2% sulphuric acid + 2 grams arsenious acid in a liter. See O. Bauer, Mitteilungen des Materialprüfungsamt (1914) page 458). The last method was used in the experiments at the Material prüfungsamt.

In the 1% sodium chloride solution, in all cases corrosion increased somewhat with increasing copper, the individual values showing considerable variation. The three kinds of steel behaved similarly.

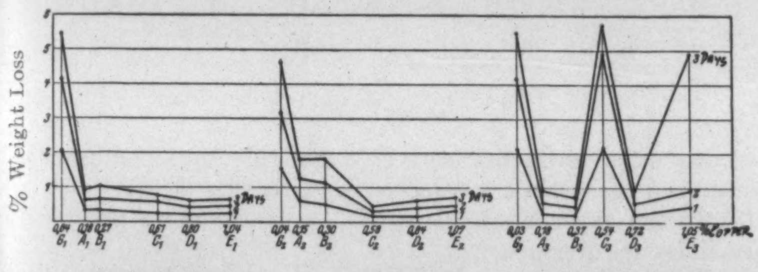


Soft Steel Structural Steel 0.25–0.35 C Steel

Fig. 7—Corrosion Tests in the Atmosphere (Staatlichen Materialsprüfungsamt)

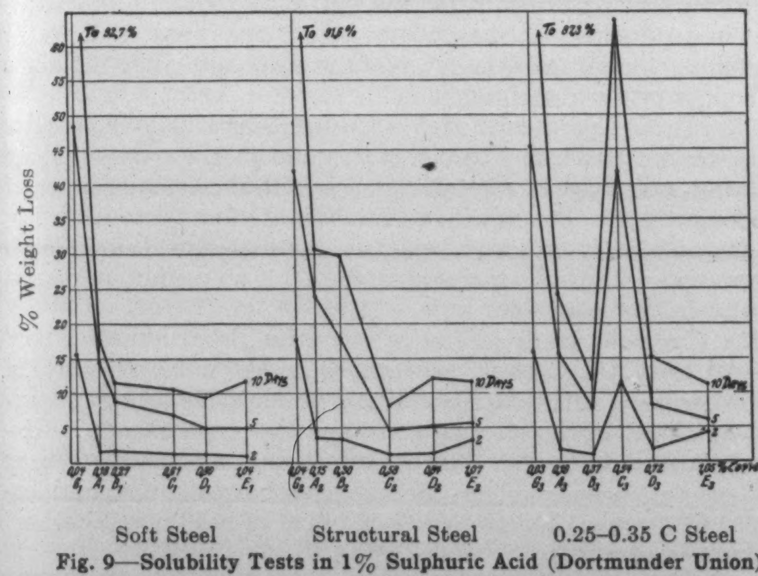
In distilled water, there is a definite decrease of corrosion with increase of copper. The 0.25–0.35% C steel showed a somewhat less tendency to corrode than both of the other kinds of steel. The loss in weight was about 1/10 that in sodium chloride.

(*g*) *In the atmosphere* (Fig. 7). In this series the specimens were hung freely in the atmosphere for 3, 6 and 9 months (Feb. 23–Nov. 23, 1928). In all cases corrosion decreased with increase of copper the greatest decrease lying always between the almost copper-free sheets and the sheet containing about 0.2–0.3% Cu. Further increase of copper only produced an inconsiderable difference in the behavior of the three kinds of steel.



Soft Steel Structural Steel 0.25–0.35 C Steel

Fig. 8—Solubility Tests in 1% Sulphuric Acid (Staatlichen Materialsprüfungsamt)



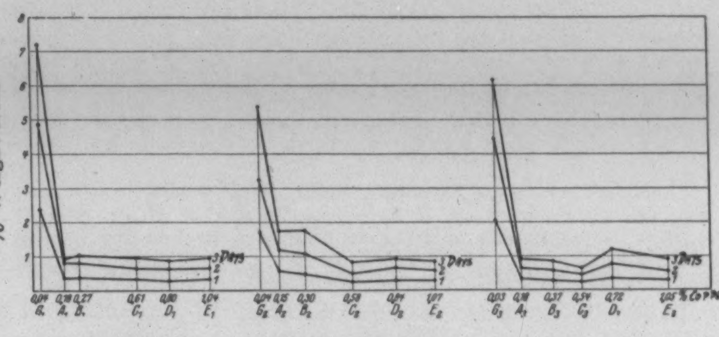
Soft Steel Structural Steel 0.25–0.35 C Steel

Fig. 9—Solubility Tests in 1% Sulphuric Acid (Dortmunder Union)

(*h*) *In 1% sulphuric acid* (Figs. 8 & 9). With a similar period of time (2 days) the solubility experiments of the Dortmunder Union gave a considerably greater loss in weight than the experiments of the Materialprüfungsamt undoubtedly due to the fact that the experiments at the former laboratory were carried out in summer and at the latter in winter. The acid was also renewed after five days in the experiments at the Dortmunder Union.

A small copper addition of about 0.15–0.30% in all cases produced a very considerable decrease in acid solubility. Further increase of copper had only an inconsiderable influence on the solubility in acid. Material C-3 showed an extraordinary increase in acid solubility, possibly due to its high phosphorous content (0.09%) since it is general experience that phosphorus increases acid solubility. Specimens B-2 (0.085% P) in Fig. 9 and E-3 (0.085% P) in Fig. 8 also showed an increase of solubility.

The three materials, if one overlooks the remarkable behavior of C-3 showed no real difference against acid attack.



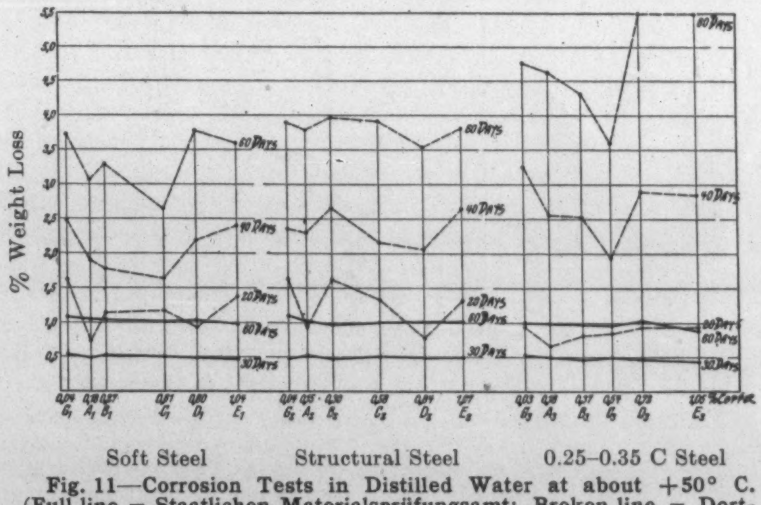
Soft Steel Structural Steel 0.25–0.35 C Steel

Fig. 10—Solubility Tests in 1% Hydrochloric Acid (Staatlichen Materialsprüfungsamt)

(*i*) *In 1% hydrochloric acid* (Fig. 10). A small copper addition (0.15–0.18%) decreased the solubility considerably. A further increase of copper produced no further effect. Material C-3 (high phosphorus) did not show an increased solubility in hydrochloric acid as it did in sulphuric acid.

The three kinds of steel showed no appreciably different behavior against hydrochloric acid.

Corrosion Experiments at +50° C.—In the experiments at + 50° C. (122° F.) at the Materialprüfungsamt the glass beakers containing the specimens were placed in an iron vessel walled around with brick and heated by electricity. During the day (about 8 hours) the temperature was held at +50°; during the night it cooled to room temperature. The evaporated water was replaced daily with distilled water. The period of test was 30 and 60 days. At the Dortmunder Union the temperature during the day (about 12 hours) varied from 50–60°. The period of test was 20, 40 and 60 days.

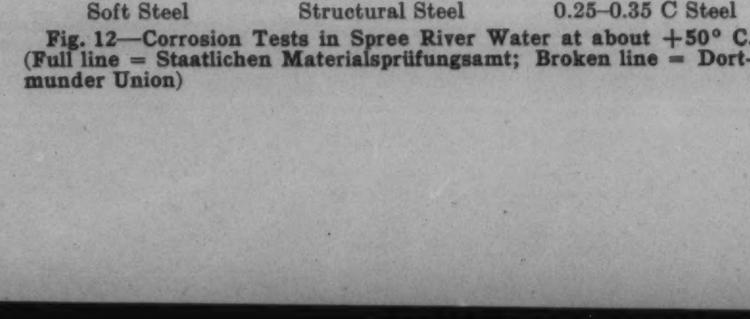


Soft Steel Structural Steel 0.25–0.35 C Steel

Fig. 11—Corrosion Tests in Distilled Water at about +50° C. (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

(*a*) *In distilled water at +50° C.* (Fig. 11). No inhibitive influence of copper was observed at the Materialprüfungsamt. The results at the Dortmunder Union varied considerably. With soft steel and 0.25–0.35% C. steel at the longer time of exposure there was a decrease of corrosion at about 0.6% Cu.

(*b*) *In river water at +50° C.* (Fig. 12). At the Materialprüfungsamt no inhibitive influence of copper was observed. At



Soft Steel Structural Steel 0.25–0.35 C Steel

Fig. 12—Corrosion Tests in Spree River Water at about +50° C. (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

the Dortmunder Union only the 60-day test showed a decrease of corrosion with increased copper. The individual values varied considerably and with higher copper (about 0.6%) corrosion increased. All three kinds of iron behaved practially alike.

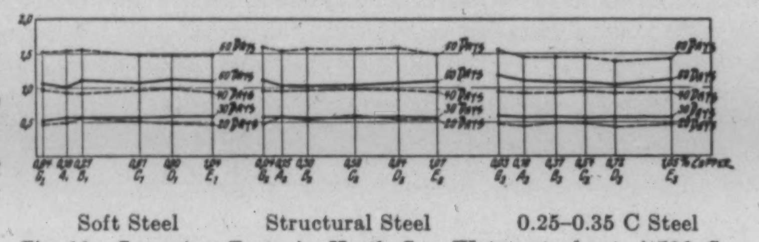


Fig. 13—Corrosion Tests in North Sea Water at about +50° C. (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

(c) *In North Sea water at +50° C.* (Fig. 13). Neither in the investigation at the Materialprüfungsamt nor at the Dortmunder Union was there observed an inhibitive influence of copper on corrosion tendency. The three kinds of steel were all strongly corroded.

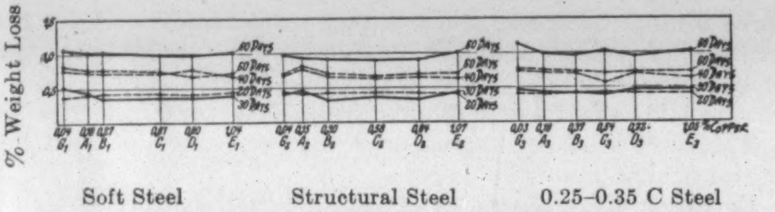


Fig. 14—Corrosion Tests in Humic Acid Water at about +50° C. (Full line = Staatlichen Materialsprüfungsamt; Broken line = Dortmunder Union)

(d) *In water containing humic acids at +50° C.* (Fig. 14). The corrosion tendency of three kinds of steel was not appreciably affected by increase of copper content. They all behaved similarly.

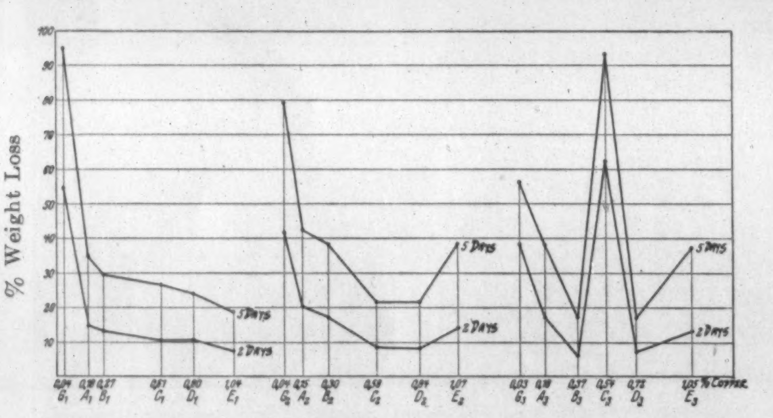


Fig. 15—Solubility Tests in 1% Sulphuric Acid at about +50° C. (Dortmunder Union)

(e) *In 1% sulphuric acid at +50° C.* (Fig. 15.) A small copper addition to the almost copper free material produced in all three kinds of steel a very considerable decrease of acid solubility. Further increase of copper produced a lesser diminution. The soft steel (almost copper-free) in comparison with the other steels showed the greatest acid corrosion. The same behavior of the high phosphorous material was observed in the experiments at room temperature.

Corrosion Experiments with Sheet Specimens with Scale.—In place of the polished specimens sheets measuring 150 × 150 × 0.5 mm. (6 × 6 × 0.19 inch.) were used. These were annealed at 900° C. (1652° F.) and cooled in the furnace. The specimens were provided with two holes, weighed and suspended in 5000 cc. of experimental solution so that they were about $^4/_5$ immersed. The experimental solutions were

(a) Tap water (purified Ruhr water)—period of test, 15 months.

(b) North Sea water—period of test, 15 months.

(c) 0.5% hydrochloric acid—period of test, 30 days.

(d) Saturated steam—period of test, 15 months.

In experiments (a), (b) and (c) the experimental solutions were always renewed after 14 days. Distilled water was added daily to replace the evaporated water. The temperature varied between +20° and +25° C. (68° and 77° F.) In experiment (d) the sheets were hung on rubber-insulated rods in a vessel of 80 liter capacity containing 10 liters of water, the distance between the under edge of the sheets and the surface of the water being 20 cm. (7.87"). This vessel was heated from beneath and the evaporation replaced daily.

In all experiments there was a uniformly moderate decrease of corrosion with increasing copper. The greatest loss in weight was suffered by the sheets suspended in steam.

General Summary

I Corrosion Experiments with Sheets without Roll Scale

(*a*) *At room temperature*

(1) In the corrosion experiments in distilled water, in water containing humic acids, in alternate wet and dry immersion in distilled water and in the atmosphere, corrosion decreased slightly with increasing copper content.

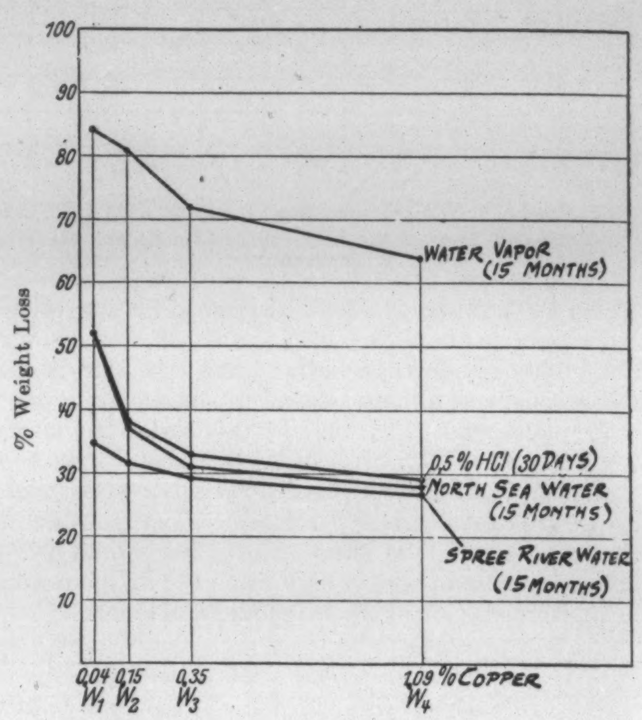


Fig. 16—Corrosion Tests on Sheets with Roll Scale (Dortmunder Union)

(2) In the experiments in river water only the structural steel showed a decrease in corrosion with increasing copper.

(3) In the experiments in North Sea water there was no definite influence of copper.

(4) In the alternate wet and dry experiments in 1% sodium chloride corrosion increased in all cases with increasing copper.

(*b*) *At about +50° C.*

(5) In the experiments carried out at the Materialprüfungsamt in distilled water, river water, North Sea water and water containing humic acids there was observed no inhibitive influence of copper on corrosion tendency.

(6) In the experiments at the Dortmunder Union the results were very variable in distilled water and in river water, some showing a decrease of corrosive attack with increasing copper at the longer times of exposure in distilled water, and some showing an increase in river water, while in the experiments in North Sea water and water containing humic acids no definite influence of copper was observed.

(7) The three kinds of steel, "soft steel," "structural steel" and "0.25–0.35% C steel" generally behaved similarly, only in the experiment with water containing humic acids (at room temperature) and in the alternate wet and dry experiments in distilled water did the 0.25–0.35% C steel show a somewhat lesser tendency to corrode. The difference was, however, not considerable. Of any real superiority of one kind of steel over another, nothing can be said.

(*c*) *In sulphuric and hydrochloric acids*

(8) The acid solubility of iron was extraordinarily decreased by a small copper content at room temperature as well as at about +50° C. (122° F.). Most of the decrease occurred between the almost copper-free specimen G and the specimens with from 0.2 to 0.3% Cu.

(9) At room temperature the three kinds of steel showed very little difference against 1% sulphuric and 1% hydrochloric acid. At +50° C. the soft steel showed the greatest corrosion in 1% sulphuric acid compared with the structural steel and the 0.25–0.35% C steel.

(10) A high phosphorous content with the simultaneous presence of copper appears to promote the solubility in sulphuric acid to a considerable degree.

II Corrosion Experiments with Sheets with Mill Scale

In the experiments with sheets with mill scale, corrosion decreased uniformly with increasing copper content in all cases tap water, North Sea water, 0.5% sulphuric acid and saturated steam.

In the specimens without mill scale a stronger inhibitive influence of the higher copper contents was observed only in the acid solutions. In other cases the results were variable. Generally where a reduction of corrosion with increase of copper was detectable, the greatest decrease was between copper-free material and material containing 0.2–0.3% Cu. A further increase of copper to about 0.6% resulted in a decrease of corrosion in only a few cases such as with tropic temperature in fresh and North Sea water. The influence of copper was, in all cases, more definite at the longer periods of time.

Corrosion and Metal Protection in Boiler Practice[1]

By R. Stumper

A Translation

The causes of the corrosion of boiler plate by the feed water can be divided approximately as follows:

1. Corrosion due to free acids.
2. Corrosion due to dissolved gases.
3. Corrosion due to heat accumulation.
4. Corrosion due to galvanic local currents.
5. Corrosion due to cold working.
6. Corrosion due to potential differences on a minute surface (pitting).

The most peculiar type of corrosion is that caused by the accumulation of heat. Despite the fact that it occurs very frequently, its mechanism is least known, so that it will be profitable to examine this phenomenon more closely. This is all the more necessary since Eberle's[2] work on the heat conductivity of scale has questioned our views regarding this type of corrosion.

The corrosion of boiler plates due to heat accumulation[3] occurs below heat-insulating scale deposits. It is to be assumed that no corrosion occurs below oil crusts and scale containing considerable oil since the oil, as a rule, prevents the wetting of the boiler plate surface. Corrosion due to heat accumulation arises chiefly in the presence of substances in the boiler water decomposed by heat. These are principally the salts splitting off hydrogen ions, e. g., magnesium chloride, ferric chloride, bicarbonates, calcium chloride, and after that, the compounds giving off oxygen, e. g., nitrates and organic compounds.

Furthermore, the scale itself can be the source of chemical changes, as a result of which corroding substances are split off. To these belong, for instance, the reduction of calcium sulphate by the organic impurities in the scale and the liberation of carbon dioxide from calcium carbonate and organic compounds. We must also consider possible chemical cycles in the more or less closed porous cavities.

As yet we can only make conjectures about these important problems, conjectures which still lack an experimental basis. How uncertain these inferences as to the causes of corrosion in steam boilers are, is known to every one who concerns himself with these questions.

The hydrolysis of magnesium salts, especially of magnesium chloride, is probably the most certainly known cause of corrosion. These corrosions occur even on clean boiler plates, in much greater measure, however, under the scale and, recently, also in high-pressure boilers, where higher temperature differences prevail between boiler plate and water. In the development of high-pressures, temperature relations have been created in the boiler which previously existed only below the scale deposit and, in general, therefore, an increase in the speed of corrosion in the high-pressure boilers is certainly to be expected.

The essential action of boiler scale in corrosion phenomena depends upon the following circumstances:

1. Elevation of the boiler plate temperature, whereby the speed of corrosion, in accordance with the reaction velocity-temperature rule, is increased $1^1/_2$ times per 10° C. rise in temperature. The greatest factor in these corrosion phenomena is doubtless due to this condition.
2. Alterations of concentration in the water at the boundary surface: plate-water.
3. Formation of chemical cycles in the more or less closed porous cavities, e. g.,

$$\begin{tikzcd}
FeCl_2 + 2H_2O \arrow[r] & 2HCl + Fe(OH)_2 \text{ (Rust)} \arrow[d] \\
FeCl_2 \arrow[u] & Fe \text{ (Plate)} + 2HCl \arrow[l]
\end{tikzcd}$$

That in all transformations of this type the endothermic reactions are accelerated by temperature increase need only be mentioned here. The systematic examination from this viewpoint of the various possible reactions would doubtless greatly advance our knowledge of corrosion and scale formation in the steam boiler and particularly in the high-pressure boiler.

The presence of liquid water at the boundary between plate and scale is the prerequisite condition for the transformations, between boiler plate and boiler water, below the boiler scale. Eberle questions this possibility and hence the development of corrosion below the scale: "Of importance for the heat conductivity of a porous body, finally, is the question, with what material its cavities are filled." From the following consideration we obtain the relations for the scale during working: A heated wall, e. g., a tube wall, has a somewhat higher temperature than the temperature of evaporation corresponding to the pressure of the boiler because there appears, even though slight, a resistance to the transmission of the heat from the wall to the water. If scale is deposited on the heating surface, the wall temperature rises, corresponding to its insulating capacity. The resistance to the transmission (of heat) to the water now appears on the inner surface of the scale and the temperature of the coating is everywhere higher than that of the water. Since the same pressure prevails in the cavities as in the boiler, only superheated steam can exist in them.

Eberle proceeds from this assumption—which is logical, indeed, but which by no means has been satisfactorily established experimentally—in order to measure the heat conductivity of scale. Since the coefficients of heat conductivity of superheated steam and air are practically the same at the temperatures in question, he investigates the material—in the form of artifically compressed cakes—in the dry condition. For this reason, too much importance for steam boiler practice must not be assigned to Eberle's results, especially as these results are, in part, in direct opposition to our existing experiences in practice. We shall merely mention at this point that, according to Eberle, the calcium sulphate scale, by virtue of its greater density and, accordingly, its higher coefficient of heat conductivity, is the least harmful. Eberle also states that the calcium sulphate scale consists, as a rule, of an aggregate of irregularly oriented crystals. I can by no means confirm this observation; on the contrary, most of the calcium sulphate scales known to me showed a transcrystalline structure. By this we understand a structure consisting of crystals all (or most) of which have developed in the direction of the flow of heat and have, therefore, oriented their longitudinal axes parallel to the flow of heat. A scale investigated had the following chemical composition:

---

[1] Translated from *Korrosion und Metallschutz*, Vol. 5, October 1928, pages 230–235. Previous communication: *Korrosion und Metallschutz*, Vol. 4 (1928) page 2.

[2] Ch. Eberle & Ch. Holzhauser, *Archiv für Wärmewirtschaft*, Vol. 9 (1928) page 170.

[3] R. Stumper, "Chemie der Bau- u. Betriebsstoffe des Dampfkesselwesens," Verlag J. Springer, Berlin, 1928, page 234.

Loss on Ignition	2.30%
SiO_2	0.50
CaO	39.41
SO_3	55.13
MgO	2.01

The composition of the individual salts is accordingly calculated as:

Calcium sulphate	93.71%
Calcium silicate	1.30
Magnesium hydroxide	2.91

From this discussion it is evident that the highly interesting work of Eberle shows several weak points and that, further, it starts from an assumption that requires a more exact experimental basis. Even though the results of these investigations must be accepted with reservations, pending further developments, nevertheless Eberle's work merits our complete attention for it is rich in stimulating suggestions. In the following we shall report only on corrosion damages that appeared beneath a calcium sulphate scale deposit on the water tube of a combined fire tube-exhaust gas tube boiler.

The boiler investigated having 303 m.² of heating surface and 10 at. working pressure, was affected by pronounced corrosions. This is a triple fire tube boiler with superimposed exhaust gas tube boiler. The feed water enters the fire tube boiler in front and reaches the upper boiler by way of a connecting pipe in the rear. A mixture of condensate and purified raw water is used. The purifying apparatus consists of a Natrolite filter that operates similar to the Permutit purification. The corrosions were alleged to have appeared only after starting the purifier and were limited to the middle boiler, which was fed mainly with purified water.

Corrosion is present on the upper side and on both sides of the two upper fire tubes, and on a number of exhaust gas tubes, especially marked at their back pieces, i. e., where the hot gases enter the tubes. Fire and exhaust gas tubes are coated with scale, the former with a 3–10 mm. thick crust, the latter with an 0.8 mm. layer. Individual exhaust gas tubes were completely perforated at the corroded end. Here the corrosion manifested itself almost exclusively on the upper side of the tube. With the exception of the perforated places, nothing of the corrosions was to be seen externally. They had to be freed by knocking on the firmly adherent scale. The strongly corroded places, to be sure, were recognized by local round or oval bulges, covered by scale, but which, nevertheless, were often burst in the middle, through which the red-brown ferric oxide beneath was visible.

This corrosion belongs, as the present investigation shows, to the corrosions due to heat accumulation beneath a scale deposit. To throw light on the more immediate causes, the material, as well as the feed water and the scale, were subjected to a thorough examination.

(*a*) *Material.* The exhaust heat tubes examined are seamless, show no rolling defects and also no noteworthy segregation. They consist of soft silicon (open-hearth) steel. The material cannot be held accountable for the corrosion.

(*b*) *Feed water.* Below are given the analyses of two samples of water-purified and unpurified.

	Unpurified Water	Water Purified with Natrolite
Dry residue at 180°	248.0 mg./l.	114.0 mg./l.
Ignition residue	124.0	72.0
Loss on ignition	106.0	42.0
CaO	33.0	20.0
MgO	19.10	9.37
Al_2O_3	3.0	2.0
Fe	trace	trace
HCO_3	24.4	39.65
SO_3	28.84	11.67
Cl	31.95	14.20
Na_2CO_3	0	0
NiO_2	4.0	3.0
Nitrates	trace	trace
Total hardness	5.97° hard.	3.32° hard.
Temporary hardness	1.12	1.82
Permanent hardness	4.85	1.50
Free carbon dioxide	8.80 mg./l.	4.40 mg./l.
Oxygen	2.80 mg./l.	11.85 mg./l.

The unpurified water belongs to the soft waters. It contains these corroding impurites: carbon dioxide, oxygen, nitrates and chlorides. The purified water is lower in salts than the unpurified, due to the addition condensation water. If one considers this dilution, then it appears that the process of purification worked badly. The high oxygen content of the purified water is striking.

The boiler water itself showed, after an approximately 20-day operation, 62.8° lime hardness and 13.72° magnesia hardness. The chlorine content amounted to 74.5 mg./l. Nitrates were abundant. The water was alkaline, but contained only about 5 mg./l. Na_2CO_3.

The presence of nitrates, chlorides ($MgCl_2 + CaCl_2$), bicarbonates, carbonic acid and oxygen can here be held accountable for the corrosion.

(*c*) *Scale.* We first call attention to the fact that the appearance of the scale differed on the upper and lower side of the exhaust heat tubes. On the upper side the coating was yellowish-white, dense, firmly adherent, smooth and about 0.8 mm. thick; on the lower side, in contrast, gray-brown, 1–1.5 mm. thick, granular-rough, porous and softer. The composition of both deposits was likewise different:

	Upper Side	Lower Side
Loss on ignition	2.10%	8.30%
SiO_2	1.70	9.85
CaO	37.15	27.43
MgO	2.73	10.95
Fe	2.57	4.15
SO_3	54.52	39.82

The scale deposit of the upper side, accordingly, consisted of about 90% $CaSO_4$, while that of the lower side contained only about 65% $CaSO_4$.

About 5 times as much SiO_2 and 4 times as much MgO were deposited on the lower side than on the upper. These differences in one and the same tube, in one and the same boiler water, are very considerable and bear eloquent testimony to the fact that the processes in scale formation are very complex. How these differences are to be explained remains for the present an open question. The structure of both scale formations, corresponding to the analysis, was also somewhat different.

One can picture the causes of the corrosion as follows:

The corrosion appears beneath a scale deposit, chiefly at the hottest places of the exhaust heat and fire tubes. It is a typical corrosion due to heat accumulation. The corrosion has arisen from the increased hydrolysis of the magnesium chloride, associated with the liberation of oxygen from the nitrates. The dissolved gases and the carbon dioxide, liberated from the bicarbonates, have assisted. The corrosion is accordingly the combined effect of the scale (heat accumulation) and the electrolytes. That the water can actually penetrate the scale deposit to the boiler plate surface is proved by the sufficient porosity of the scale (15–25%).

How does the question of the causes of the present corrosion shape itself in conjunction with the previously mentioned work of Professor Eberle? The absence of liquid water in the porous cavities would lead us to the two following assumptions:

Either corrosion has resulted from the steam (according to the well-known reaction $Fe + H_2O \longrightarrow FeO + H_2$) or it has occurred in the intervals between operation after the penetration of the liquid water into the porous cavities. Both assumptions are unsatisfactory, for in the case of a direct oxidation of the iron by steam, corrosion beneath the scale crust must be the rule—which by no means is the case. The circumstance, that the corrosions occur only on the hottest places refutes the assumption of the action of water exclusively in the intervals between operation. We are, therefore, compelled, as long as more cogent reasons do not oppose it, to cling to the direct effect of the electrolyte on the scale-covered plate surface during operation.

We cannot agree to the assumption of Professor Eberle that the surface of the scale-coated plate, during operation, comes in contact, not with liquid water, but only with vaporized water. To be sure, there always remains the possibility that conditions thus far, entirely unknown to us, induce corrosion of the boiler plates beneath the scale deposit.

Current Metallurgical Literature Abstracts

These abstracts are not critical, but merely review developments as they are recorded. The various classifications are numbered. This number is at the end of each abstract and will be of assistance in mounting them on cards for filing.

GENERAL (0)

The Cobalt Industry—Notes on Recent Developments. *Chemical Trade Journal*, Vol. 87, July 11, 1930, page 34.

Recent advances in the metallurgy of cobalt and its industrial uses are summarized in the "Bulletin of the Imperial Institute," No. 2 (1930) Canada and Belgian Congo each contribute two-fifths of the world's production. The metallurgical practice with the copper-cobalt ore of Katanga, Belgian Congo is outlined. The increasing use of cobalt-tungsten alloys is noted. WHB(0)

Alloy Steels. E. C. Smith. *Proceedings Engineers' Society of Western Pennsylvania*, Vol. 46, July 1930, pages 205–222.

Briefly considers use of various alloying elements. Includes discussion. (0)

The Institute of British Foundrymen. Wesley Lambert. *Metallurgia*, Vol. 2, July 1930, page 87.

A review of the past year's activities. JLG(0)

The International Congress of Mines, Metallurgy and Applied Geology at Liege, and the International Foundry Congress. *Metallurgia*, Vol. 2, July 1930, pages 97–98.

Describes meeting of the Sixth International Congress held at Liege from June 22 to 28, 1930, with particular reference to the Foundry Sub-Section of the Congress. JLG(0)

The Foundrymen's Convention at Middlesbrough. *Metallurgia*, Vol. 2, July 1930, pages 89–93.

Report of the Annual Convention of the Institute of British Foundrymen held June 17 to 20, 1930. Includes abstracts of the papers presented. JLG(0)

The Broad View. *Metallurgist*, Jan. 1930, page 2.

It is claimed that existing demarcation between ferrous and non-ferrous metallurgy is fundamentally unsound and undesirable; but the field of ferrous or non-ferrous metallurgy is so extensive that no one can cover the whole of either, and still less of both. The practical question arises how dangers and evils of excessive specialization are to be met. Discusses joint meetings and discussions bringing together those who deal with the same material or the same subject from widely different points of view. (0)

PROPERTIES OF METALS (1)

Thermal Conductivity. J. W. Donaldson. *Metallurgia*, Vol. 1, Feb. 1930, pages 119–120.

Notes on some outstanding investigations on ferrous and non-ferrous metals and alloys. *International Nickel Co. Abstract Bulletin.* (1)

The **Permeability of Hot Metals to Hydrogen.** B. C. Hendricks & R. R. Ralston. *Journal American Chemical Society*, Vol. 51, Nov. 1929, pages 3278–3290.

Experimental data on pure zinc (350 and 373° C.), pure copper (568 and 632° C.) and electrolytically refined nickel. Relations of diffusion rates to pressure at constant temperatures and relations of diffusion rates to temperatures at constant pressure. (1)

Heat-Treatment, Ball-Hardness and Allotropy of Lead. F. Hargreaves (Southern Railway). *Institute of Metals, Advance Copy* No. 540 (1930) 19 pages.

Accurate ball-hardness tests of samples of very pure (99.999%) lead quenched from various temperatures suggest allotropic transformations at 187 and 228° C. By different heat treatment the hardness of this lead can be made to vary from 3.1 to 5.0. The presence of 0.005% of tin inhibits these changes while equal amounts of cadmium and bismuth do not. In each case examined, quenching increased the ball-hardness. JLG(1)

Physical and Chemical Properties of Beryllium. (Physikalische und Chemische Eigenschaften des Berylliums.) K. Illig. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 74–82.

A review of the literature dealing with the physical properties of Be and its behavior toward acids, bases, gases and various oxides. 31 references. (1)

Rolled Zinc. *Research Bulletin of the New Jersey Zinc Co.* Oct. 1929, 54 pages.

Designed as a reference book on all phases of wrought zinc, especially rolled zinc. Is divided into 6 chapters, including Composition and Mechanical Properties, Metallography, Physical Properties, Chemical Properties, Fabrication and Finishing. Contains 19 illustrations, numerous tables, some bibliographic references and a thorough index of 6 pages. ACW(1)

Melting Point of Pure Tellurium. A. Simek & B. Stehlik. *Collection of Czechoslovak Chemical Communications*, Vol. 2, May-June 1930, pages 304–313.

Contains bibliography of 8 references. The melting point of spectroscopically pure tellurium in vacuo was found to be 452.0° C. Melting in hydrogen or carbon dioxide lowered the melting point about 0.15 and 0.2° C. respectively per atmosphere of pressure. This is explained by the absorption of these gases in the element. Tellurium was found to contract on freezing. The cooling curve below the melting point showed no indication of a transformation. JLG(1)

The Magnetic Behavior of Nickel and Iron Films Condensed in Vacuum upon Various Metal Backings. J. H. Howey. *Physical Review*, Vol. 34, Dec. 1, 1929, pages 1440–1447.

An investigation of the magnetic nature of evaporated iron and nickel films deposited on various kinds of backings to determine the effect of two-dimensional strain which backing must impose upon film due to differential thermal contraction. (1)

The Dependence of Electric Conductivity of Metals at Low Temperatures on Pressure. (Zur Druckabhängigkeit der elektrischen Leitfähigkeit der Metalle bei tiefen Temperaturen.) U. Fischer. *Zeitschrift für physikalische Chemie*, Vol. 6, June 1930, pages 207–217.

The author investigated the electric conductivity in dependence on pressure down to the temperatures of liquid hydrogen employing the following materials: Pb, W, Mo, Cu, Fe and Constantan. The pressure coefficient of the resistance largely increases with falling temperatures. The earlier decrease starts the higher the characteristic temperature of the substance. The pressure coefficient of Constantan shows a minimum at about 145° C. abs. EF(1)

Selective Absorption and Reflection of Slow Electrons on Metals. (Ueber selektive Absorption und Reflexion langsamer Elektronen an Metallen.) E. Rupp. *Zeitschrift für Physik*, Vol. 58, Oct. 24, 1929, pages 145–164.

This is a communication of the Research Institute of A. E. G. Berlin in which tests concerning electron diffraction by thin metal films are discussed. Measurable permeability of these films for slow atoms has been found at 40 to be 4 volts. It is shown that different metals have maximum of absorption for electrons of certain speed. (1)

Manganese and Its Alloys. (Le Manganese et ses alliages.) R. Cazaud. *Aciers Speciaux, Métaux et Alliages*, Vol. 5, June 1930, pages 271–278. 4 references.

A review of manganese properties, production and uses. Manganese melts at 1240° C. and has a density of 7.39. According to the manganese content there are 3 classes of manganese steel: Pearlitic containing 0.20% C and up to 5% Mn or 0.80% C and up to 3% Mn; Troosto-martensitic with 0.2% C and 5–12% Mn or 0.80% C and 3–7% Mn; and Austenitic of 0.20% C and with more than 12% Mn or 0.80% C and more than 7% Mn. Steel with 13% Mn is normally non-magnetic but on cold hammering it becomes magnetic. Austenitic structure in manganese steel is maintained by water quench from 1000° C. Manganese forms a continuous series of solid solutions with copper, the solidus and liquidus having a common point at 865° C. and with 30% Mn. Manganese and aluminum form 2 non-miscible zones, one between 12 and 40% Mn at 980° C. and the other between 80 and 98% Mn at 1280° C. There are found 3 compounds: Al_3Mn, AlMn and $AlMn_3$ corresponding respectively to 38, 67 and 86% Mn. GTM(1)

PROPERTIES OF NON-FERROUS ALLOYS (2)

Copper Alloy Systems with Variable Alpha Phase Range and Their Use in Hardening of Copper. (Systeme d'alliages de cuivre avec phase alpha á limites variables et leur emploi pour le durcissement du cuivre.) Part I. M. G. Corson. *Revue de Metallurgie*, Vol. 27, Feb. 1930, pages 83–101; Part II, March 1930, pages 133–153; Part III, April 1930, pages 194–213; Part IV, May 1930, pages 265–281.

I. When one metal dissolves in another at a high temperature and precipitates on cooling some hardening effect can take place in the binary alloys, but the amount of it cannot be great because there are but a few solutions forming hard enough precipitates. The limits of solid solubility of these elements in copper narrow with the rise of the temperature as in Cu–Zn, Cu–Sn and Cu–Al systems. Metallic substances which when alloyed with Cu can harden it successfully must easily dissolve at high temperatures and form on precipitation hard but comparatively non-brittle minute particles. When two are used one must not form any compound with Cu whatever, while the second must have more affinity to it than to Cu. Taken separately one of them, but preferably both, must be soluble in solid Cu to some extent. Eutectic temperatures of Cu with these compounds must not be too low. Many ternary systems are possible but only a few realizable. Cu–Co–Si, Cu–Ni–Si, Cu–C–Si, Cu–Fe–Si and Cu–Mn–Si all harden on drawing. Binary systems Cu–Fe, Cu–Cr, Cu–Co and Cu–Si were studied. Thirteen curves and 23 microphotographs are given.

II. A study of Cu-Si series. Alpha solution range increases with the temperature. Limits of solid solubility at low temperatures are not definite. The secondary constituents slowly precipitate along cleavage planes. For practical purposes the limit of solid solubility can be placed at 3% Si. Long annealing at 200–300° drops it to about 2%. Normalizing, rolling and annealing permits following the changes in physical properties as related to increasing Si content up to 2.3% where the results become irregular. Above 2.3% the excess Si precipitates causing changes in hardness. Hardness of alloys quenched and drawn at 400–500° for 3–6 hours increases, reaching a maximum of 280 Brinell with 6.7% Si. Hardness does not affect tensile strength but strongly changes elongation. Conductivity figures are in agreement with Norbury's (*Journal Institute of Metals*, Vol. 29 (1923) page 423; Vol. 33 (1925) page 91). For low Si content the improvement in conductivity is caused by precipitation of more resistant β-phase. With higher Si content α-precipitates. The structure of low Si alloys is strongly affected by heat treatment, though the physical properties remain almost the same. Grain size increases with Si. A constitutional diagram of Cu-Si is given.

III. A study of hardening copper by heat treating its alloys with silicides. In Cu–Cr–Si systems Si greatly increases the solubility of Cr and its precipitation at lower temperature ranges. The limits of its solubility are not as sharp as in Cu–Cr system, and the temperatures required for treatments are lower than those necessary for Cu–Cr alloys. The mechanism of hardening presented on diagrams was studied on specimens containing 1% Cr_2Si. The use of Fe silicides did not prove to be advantageous though some hardening could be produced. Alloys with Ni_2Si and Co_2Si give optimum results. The state of solid solution does not cause the maximum resistivity because it can be increased by higher heating. High Ni_2Si alloys harden on mere cooling in the blast of air. Ductility figures are not consistent.

IV. In pseudo binary alloys like Cu with Ni_2Si or Co_2 Si annealing after quenching precipitates constituents in many different shapes. Sorbitic structure gradually (with the increasing Ni_2Si content) changes into free eutectoid precipitated at the grain boundaries, reappearing again as a complex structure at 9.6% followed by the former structure with 12%. Alloys produced by keeping Si at 2.5% and increasing Ni to 50 and 90% could be worked only when a little Mg was added in casting. Their properties were similar to those obtainable on hardening rich Cu–Ni alloys. Constitutional diagram given shows that up to 30% Ni the lower limit of solid solubility remains practically constant, being 0.10% Si at lower temperatures and 1.0% Si at 975° C. Above 30% Ni the proportion of Si remaining in solution increases. With 50% Ni no hardening or precipitation occurs with less than 0.8% Si. No free silicides can be found after 975° quench with less than 2.3% Si. Hardening is produced by formation in Cu alloys of Ni_2Si and Co_2Si. FeSi cannot be used for the purpose. The existence of Ni_2Si is well established. Co_2Si is unstable. Preparation of the alloys does not call for any special precautions. Six groups of industrially interesting alloys are described and their heat treatment is given. A comparison with the alloys of Reed and Greaves (*Journal Institute of Metals*, 1920) is given. Si can be replaced with Be which forms Ni_2Be. Corrosion resistance of the alloys is average. The influence of Zn, Al, Sn, Mn, Mg, Fe and Pb is outlined. Alpha brass and bronze can be hardened by dissolving in them Ni and Si and heat treating. Figures of the results are given. The paper has 93 photomicrographs and 59 diagrams. JDG(2)

Magnesium-Base Alloy Sand-Castings. Proposed tentative specifications, in Report of Committee B-7, *Preprint* 23, June 1930 Meeting, *American Society for Testing Materials*, 3 pages.

Covers commercial castings of specific gravity 1.9 or less. Three alloys are specified: No. 1, 5.5–8.5% Al, 0.2% Mn, 1% Cd, 0.2% max. Si, other metals 0.3% max., Mg 90% min. Recommended for general casting work. Tensile 24,000 lbs./in.^{2}, elongation 4% sand cast. Sand cast and heat treated 29,000 and 6%. No. 2. 8–12% Al, 0.1% Mn, Cu 2.5% max., 0.2% max. Si, other metals 2.5% max., Mg 87% min. Copper should be kept low for maximum corrosion resistance. Tensile, sand cast 20,000 lbs./in.^{2}, elongation $^1/_2$ %. No. 3. 1.7–2.3% Al, 0.2% Mn, 3.5–4.5% Cu, 1.6–2.4% Cd, 0.2% max. Si, other metals 0.3% max., Mg 91% min. This has 50–75% greater thermal conductivity than alloys 1 and 2. Tensile, sand cast 21,000 lbs./in.^{2}, elongation 2%. All test bars to be separately cast in green sand, breaking section not machined. HWG(2)

Hiduminium—a new alloy development. *American Metal Market*, Vol. 37, June 26, 1930, pages 3–4, *Metallurgia*, Vol. 2, June 1930, pages 52-53.

Hall and Bradbury of the Rolls-Royce Co. have produced a new alloy known as "Hiduminium" RR 50. The composition approximates: copper, 0.5–5.0, nickel, 0.2–1.5, magnesium, 0.1–5.0, iron, 0.6–1.5, titanium, 0–0.5, silicon, 0.2–5.0, aluminum, remainder. Investigations with compositions containing elements within these wide limits have resulted in the production of 4 grades, one for sand and die-castings for pistons, one for general purposes, one for forgings for general purposes, one for forgings for high-quality pistons. A suitable heat treatment is applied. Claims for the alloy are: greater lightness and toughness than aluminum alloys formerly used and many times their resistance to fatigue under the stress of heat and prolonged vibration. It is cheaper. Tables show the hardness of a specially developed alloy, Hiduminium RR 53 at various temperatures as cast and in the heat treated condition, also the tensile strengths. Greater care is needed in machining the casting than in the aluminum-silicon alloys. JLG+WHB(2)

The R. R. Group of Aluminum Alloys. R. W. Harvey-Bailey. *Nickel Bulletin*, Vol. 3, Aug. 1930, pages 252–256.

The chemical analyses, physical and mechanical properties, heat treatment, properties at elevated temperatures and results of alternating bend test given in tables for Rolls-Royce alloys. (2)

Zinc-Base Die-Castings. Report of Subcommittee XV of Committee B-2, *Preprint* 19, June 1930 Meeting, *American Society for Testing Materials*, 9 pages.

The Sub-committee has been reorganized into an independent committee and will hereafter be designated as B-6. Data on tensile and impact properties and expansion changes of a series of zinc-base die-casting alloys are given in the initial condition, after heating in paraffin 20 days at 95° C. after 50 and 60 days in water vapor at 70° C. and after 10 and 20 days in water vapor at 95° C. Two alloys containing 4% aluminum and 3% copper with 0.03 and 0.11% Sn, 0.04 and 0.24% Pb and 0.03 and 0.14 Fe corroded all the way through in the 3 more severe water vapor tests. Only one of 9 alloys tested survived all the water vapor tests in good condition. This contained 4% Al, 3% Cu, 0.12% Mg, no tin and lead and cadmium below 0.01% each. A similar composition with about 0.03% Pb and 0.05% Cd was badly attacked. The committee states, "The disintegration of certain types of zinc-base, die-casting alloys has been a major deterrent to their wider use. This disintegration is due to intercrystalline oxidation. The susceptibility of the alloys to this inter-crystalline oxidation is affected by the conditions under which the structural change, in which the β-phase transforms into $\alpha + \gamma$-phase, occurs. This growth and oxidation of zinc-base die castings in the presence of water vapor has been shown to be accelerated by the presence of tin and lead as impurities and to be reduced by the addition of small quantities of magnesium. It has been clearly established that the use of zinc of the highest purity commercially obtainable (0.02% maximum impurities) is essential where the maximum longevity is expected in the presence of moisture." HWG(2)

Use of Platinum Metals in the Chemical Industry. (Die Verwendbarkeit der Platin-Metalle in der chemischen Industrie.) Edmund Richard Thews. *Chemische Fabrik.*, Vol. 7, Feb. 12, 1930, pages 49–53.

The platinum group consists of 1. platinum and palladium, 2. iridium and rhodium, 3. osmium and ruthenium. Pt and Pd are the only ones attacked by aqua regia and Pd dissolves in boiling HCl, otherwise all are insoluble in acids. All are attacked by strong alkalies and alkali cyanides at red heat. Ir, Os, Rh and Ru are not attacked by Cl, I and F. Cl attacks Pt and Pd, I attacks Pd and F attacks Pt at red heat. In general Ir shows highest resistance to chemical attack, then in order, Ru, Rh, Os, Au, Pt and Pd. With the exception of Pt and Rh the others form oxides at high temperatures. 100% pure Pt is used only for thermocouples. Usually it contains 1% Ir. Hard Pt contains 5–30% Ir. Os and Ru are not as good as Ir for alloying with Pt. Pt is also used for catalysts. *Pt-Ir* alloys are the most important alloys. They have better resistance to HCl, H_2SO_4 and aqua regia than pure Pt. The 30% Ir alloy is practically insoluble in aqua regia. The hardness and strength of Pt are increased by additions of Ir up to 40% Ir. Pt-Ir alloys lose weight slightly when heated above 900°. The 10–20% Ir alloy is used for fuse wires for explosives. Due to its scarcity Ir is very expensive. The alloy 70% Pt 5% Ir, 25% Pd is sometimes used as a substitute. *Pt-Pd* alloys are softer than the others and are not used much. Pt-Pd-Au alloys are more important. *Pt-Os.* Os hardens Pt very much. Os oxidizes below a red heat and the oxide, OsO_4, volatilizes and is very poisonous. Pt-Os alloys are not used. Os-Ir alloys are used for fountain pen points on account of their hardness. *Pt-Rh* alloys have good properties, but are expensive. They do not oxidize. The 10% Rh alloy is used extensively for thermocouples. The hardness is intermediate between the Ir and Pd alloys. Pt-Rh is good up to 1600° C. It is used as a catalyst for HNO_3 manufacture. The 3.5% Rh alloy is used for laboratory articles. Also for electric furnace units. *Pt-Ru* alloys are similar to Pt-Os, but the poisonous effects are not as bad. 91 Pt, 5 Ir, 4 Rh equals 85 Pt, 15 Ir, in hardness. Ir-Ru alloys are more important. 10 Ir, 90 Ru is used for thermocouples for 1600–2000° C. *Pt-Au* alloys up to 60% Au cannot be worked. The 10–15% Pt alloy is used because it is resistant to conc. H_2SO_4, alkali carbonates and nitrates and other chemicals. CEM(2)

The Platinum-iridium Alloys. (Die Platin-Iridium-Legierungen.) Karl B. Thews. *Deutsche Goldschmiede-Zeitung*, Vol. 33, June 14, 1930, pages 271–272.

Discusses uses of Pt-Ir alloys in jewelry and particularly their properties. As Ir is added to Pt the hardness increases until 40% has been added. Ir also increases resistance to chemical attack. To prevent volatilization of Ir oxide the alloys should not be heated above 1000 or 1100° C. Curves are given to show the effect of annealing temperature on the strength of various alloys. An alloy of 70 Pt, 25 Pd and 5 Ir is sometimes used in America in place of the more expensive binary Pt-Ir alloys. Palladium does not effectively increase the hardness of Pt, but gold does. Hard alloys are sometimes produced by the addition of both Au and Pd to Pt. Typical alloys are 81 Pt, 14 Pd and 5 Au, and 95.3 Pt, 0.8 Pd and 3.9 Au. For best results the Pt content should be 2 or 3 times the Au content. JLG(2)

Aluminum Bronzes with Zinc, Silicon and Antimony. (Etude des bronzes d'aluminium speciaux au zinc, au silicium et a l'antimoine.) Armel Sevault. *Revue de Metallurgie*, Vol. 27, Mar. 1930, pages 154–173; *Comptes Rendus*, Vol. 190, Feb. 17, 1930, pages 431–434.

Several aluminum silicon bronzes were investigated by means of thermal analysis, electrical resistance, thermoelectricity, hardness and microscopic examination. Silicon increases the hardness of bronzes of the composition corresponding to $\alpha + \gamma$ range of the equilibrium diagram. Si is responsible for the formation of a complex γ-constituent. Similar investigation of aluminum bronzes containing antimony showed that Sb only partly goes in solution forming acicular structure but not of martensitic character. Hardness and brittleness are greatly increased by Sb addition. Almost all alloys were filled with fissures rendering the metal unfit for use. JDG(2)

The Significance of Hardness Values for Some Copper-Zinc Alloys. C. H. Davis & E. L. Munson. *Preprint* 49, June 1930 Meeting, *American Society for Testing Materials*, 7 pages.

The behavior of α-brass on reduction by cold rolling depends on its previous history. The hardness is dependent not only on the degree of reduction but also upon the initial grain size. Rockwell hardness and tensile strength curves are given for 67:33 Cu Zn for different percentage reduction of material with various grain sizes. Given any 2 of 3 variables, the third may be found from the curves. HWG(2)

Thermal Conductivity of Copper Alloys. II. Copper-Tin Alloys. III. Copper-Phosphorous Alloys. Cyril Stanley Smith (American Brass Co.). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 360 (1930) 11 pages.

The thermal conductivity of copper is rapidly reduced by the addition of tin until with 10.41% tin it is only 13% that of copper. Phosphorus is more powerful than tin in reducing the thermal conductivity, as 0.93% phosphorus reduces the conductivity to 13.5 that of copper. The Wiedemann Franz-Lorenz ratio with increasing tin or phosphorus increases rapidly at first, but beyond 2.0% Sn or 0.15% P remains almost constant. Contains 10 references. JLG(2)

White Gold. (Vom Weissgold.) R. Rücklin. *Deutsche Goldschmiede-Zeitung*, Vol. 33, March 22, 1930, pages 138–139.

A short review on the working properties, uses and development of white gold. There are 2 types of white gold; one containing palladium and the other no noble metal other than gold. Both types were developed independently in 1912. JLG(2)

New Silicon-Zinc-Copper Alloy. E. Vaders (Hirsch, Kupfer- und Messingwerke A. G.) *Institute of Metals, Advance Copy* No. 544 (1930) 17 pages.

The solid solubility of silicon in brass was found to be about 4% at 90% copper and about 1% at 70% copper. The alloys, especially those in which the silicon is in solid solution have valuable properties. They are stronger and more ductile than the silicon free alloys. An alloy containing 4% silicon, 15% zinc and 81% copper can be extruded to give a strong, ductile rod. The addition of either tin or nickel had a deleterious effect. The alloys containing tin, however, make good bearing metals. The alloys are recommended for permanent mold castings and die castings. Their machinability is much better than brass. Bells made from an alloy containing 81–82% copper, 4–5% silicon, 14% zinc and about 0.5% tin have the same tone characteristics as tin-bronze bell metal. Contains 6 references. JLG(2)

The Use of Nickel in Gold Alloys. *Metallurgist*, Oct. 1929, pages 153–154; Nov. 1929, pages 172–174.

A review of the properties and uses of a series of gold-nickel alloys (white gold as a substitute for platinum) with gold from 90–10 atomic percent and nickel from 10–90 atomic percent. Effects of additions of small quantities of zinc or copper or both. (2)

Brinell Hardness, Proportional Limit and Tensile Strength of Age Hardening Aluminum Alloys. (Brinellhärte, Elastizitätsgrenze und Zugfestigkeit vergütbarer Aluminiumlegierungen.) P. Melchior. *Zeitschrift für Metallkunde*, Vol. 22, May 1930, pages 175–176, 6 references.

The author set out to simplify the relationship between Brinell Hardness, proportional limit and tensile strength of age-hardening Al- alloys as represented by formulae of Bohner. In his diagrams, Melchor always plots two of the physical properties against each other which method yields simple straight line relations. EF(2)

Aluminium Bronze—A Corrosion-Resistant Alloy. Robert J. Anderson. *Metallurgia*, Vol. 2, June 1930, pages 57–60.

Contains bibliography of 20 references and 3 footnote references. The superior corrosion resistance of aluminum bronze is discussed. Its resistance against certain solutions can be increased by the addition of other elements such as iron. Tables taken from the Aluminum-bronze Manufacturers' Institute list the solutions that attack the alloy and those that it resists. It is resistant to attack by sulphuric acid, and for this reason is used in the construction of equipment for pickling steel. JLG(2)

Aluminum-Silicon-Magnesium Casting Alloys. R. S. Archer & L. W. Kempf (Aluminum Company of America). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 352 (1930) 34 pages.

The properties of numerous cast Al-Si-Mg alloys, with and without copper, were determined in an attempt to find a casting alloy stronger than the Al-Si alloys and having the corrosion resistance of these alloys. The bars were cast in sand molds and tests made on both untreated and treated unmachined bars. It was found that yield point, tensile strength and hardness increased while elongation decreased as either the silicon or the magnesium content increased. The effects of iron and copper on iron silicon alloys were also determined. The Al-Si-Mg alloys can be successfully modified, and are rather insensible to variations in casting temperature. The alloys containing magnesium were found to be as resistant to corrosion as those containing only aluminum and silicon, and they were easier to machine. Microstructures of typical structures are shown. Contains 8 references. JLG(2)

"Y" Alloy. S. L. Archbutt (National Physical Laboratory, England). *Canadian Mining Journal*, Vol. 51, Aug. 22, 1930, page 821.

An abstract. "Y" alloy consists of copper 4%, nickel 2%, magnesium 1–5%, and the remainder aluminum, and is used largely as a piston material. The alloy age-hardens after suitable heat treatment, thereby improving the mechanical properties of castings. It can be extruded, hot-rolled, forged, drop stamped and pressed. The outstanding properties are its properties at high temperatures, its elastic properties and resistance to atmospheric and marine corrosion. It has low specific gravity and high thermal conductivity. Comparison of "Y" alloy and duralumin as regards mechanical properties is made. WHB(2)

The Mechanical Properties of Gold-Alloys for Dentistry. (Die mechanischen Eigenschaftten von Goldlegierungen für die Zahnheilkunde.) *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, April 5, 1930, page 446.

The principal requirement for any alloy to be used in dentistry is absolute chemical passivity; corrosion and tarnishing must be excluded. Tammann has shown, in 1921, that those gold-alloys are fully resisting if they solidify as solid solutions and the number of their gold atoms is at least the number of their total atoms. This is the case if the amount of gold in an alloy with silver is 64.6%; with copper, 75.6%; with equal parts of silver and copper, 69.7%. The mechanical properties must be adapted to the requirements in the case. For bridge work, the same static laws must be applied as in a railway or other bridge: the material must have high tensile strength and toughness. Ha(2)

Recent Developments in Light Aluminum Alloys. (Les Recents Progres des Alliages Legers d'Aluminium.) Leon Guillet. *Genie Civil*, Vol. 96, May 3, 1930, pages 427–431; May 10, 1930, pages 449–454; May 17, 1930, pages 475–478.

Discusses the history of aluminum alloys as a supplement to the review made by this same magazine in 1924. Takes up those alloys containing 80–90% Al. Important articles and investigations dealing with the alloys are summarized. Their physical characteristics and chemical properties, their mechanical treatment and heat-treatment and their industrial utilization are discussed. (2)

Beryllium-Nickel Alloys. (Beryllium-Nickellegierungen.) G. Masing & O. Dahl. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol 8, No. 1 (1929) pages 211–219.

Beryllium dissolves in molten Ni with the evolution of much heat; the system contains one compound, NiBe, which forms a eutectic with nickel, melting at 1155° containing 5.2% Be. The saturated solid solution of Be in Ni contains 2.8% Be at the eutectic temperature and 1.4% at 800°. Alloys containing more than 1.5% Be undergo age-hardening after quenching from 1100°, a maximum hardness of 550 being obtained with the 3% alloy in 1 hour at 600°, but hardness values of over 600 can be obtained with the 2.5 and 3.0% Be alloys by prolonged annealing at 450°. These alloys after heat treatment have a tensile strength of 132 kg./mm.^{2} (187,500 lbs./in.^{2}) with an elastic limit of 110 kg./mm.^{2} (156,200 lbs./in.^{2}); they are almost as resistant as pure Ni to corrosion by dilute HNO_3 and HCl and are quite unattacked by sea water. (2)

The Properties of Pressed Bars of Electrolytic Copper, Reverberatory Copper, Arseniferous Copper, Aluminum Bronze with 4% Aluminum in Dependence on the Conditions of Pressing. (Ueber die Eigenschaften von Presstangen aus Elektrolytkupfer, Hüttenkupfer, arsenlegiertem Kupfer, Aluminiumbronze mit 4% Aluminium in Abhängigkeit von den Pressbedingungen.) P. Siebe & G. Elsner (Experimental Station of Osnabrücker Kupfer- und Drahtwerk). *Zeitschrift für Metallkunde*, Vol. 22, June 1930, pages 203–206; July 1930, pages 238–245, 7 references.

An investigation was carried out with electrolytic Cu, Cu refined in the reverberatory furnace, Cu containing As and 4% Al, respectively, to study the influence of temperature during pressing operation and annealing upon tensile strength at room and at elevated temperature, impact hardness and grain size. The samples were pressed at the lowest and highest possible temperatures. It was noticed in the As delivered bars that a low pressing temperature results in an increase of tensile strength and elongation whereas reduction of area generally decreases. At higher annealing temperature the loss in physical properties in the cold pressed material is more pronounced. This is ascribed to the larger grain growth in the bars pressed at lower temperature. The examination being extended over the whole length of the bars, disclosed that the influence of the low pressing temperature became more pronounced toward the end of the test pieces. By cold drawing, the strength of the material drawn at lower temperatures yielded larger gains while the reduction in area is decreased which, however, remains constant if higher temperatures are applied. Former observations made on MS 58 (brass with 58% Cu), concerning the influence of annealing temperature on grain size, are confirmed. EF(2)

Investigation of the Thermal Conductivity of the System Copper–Nickel. G. F. Sager. Ph.D. Thesis. *Rensselaer Polytechnic Institute, Engineering and Science Series* No. 27, June 1930, 48 pages.

Alloys made up for 80:20, 60:40, 40:60 and 20:80 Cu and Ni were made by melting Mond Ni and Cu cable, deoxidizing with 0.20% Mn and 0.17% Mg. Cu and Ni were also included. No analyses of the alloys are given. By a "dynamic" method involving the velocity with which a cyclic temperature variations progressed along a wire specimen, the thermal conductivity was studied up to about 700° C.

Thermal conductivities measured for the lowest and highest temperatures studied are as follows:

Material Cu-Ni		Temp.° C.	Thermal Cond. cal./cm./sec./° C.	Elect. Cond. mhos./cm. × 10^5
100	..	29	0.99	5.55
		497	0.93	1.99
80	20	48	0.089	0.354
		711	0.223	0.302
60	40	62	0.060	0.199
		717	0.218	0.192
40	60	52	0.058	0.188
		697	0.160	0.174
20	80	44	0.086	0.336
		693	0.203	0.196
..	100	54	0.193	0.960
		743	0.278	0.232

The thermal conductivities are in general higher than those of other investigators. The author states that the method used probably gives high results especially at the higher temperatures.

The Lorenz ratio, that of thermal to electrical conductivity, is discussed. Specific heat was determined calorimetrically. The average specific heats are given by the following equations.

Ni below magnetic transformation $S = 0.0985 + 0.0000666\ t$
Ni above magnetic transformation $S = 0.1185 + 0.0000093\ t$
80 Ni 20 Cu $S = 0.1099 + 0.000010\ t$
60 Ni 40 Cu $S = 0.1029 + 0.000010\ t$
40 Ni 60 Cu $S = 0.0987 + 0.000013\ t$
20 Ni 80 Cu $S = 0.0911 + 0.000019\ t$
Cu $S = 0.0959 + 0.0000045\ t$

The true specific heats are also given. Observations were made up to 700° or 800° C. The precision of the specific heat determinations is not discussed. HWG(2)

Silicon-Copper Alloys and Silicon-Manganese-Copper Alloys. E. Voce (British Non-Ferrous Metals Research Association). *Institute of Metals, Advance Copy* No. 543 (1930) 31 pages.

The mechanical and physical properties of both cast and worked alloys were studied. Alloys up to 1% silicon were drawn into 0.050" wire without difficulty. The electrical conductivity of these cold drawn wires decreases rapidly with increasing silicon while the strength increased. The cast and rolled alloys had properties similar to ordinary bronze. Machining properties are improved as silicon increases. Silicon-copper alloys containing up to 4$^1/_2$% silicon can be hot rolled easily. The hot rolled 4$^1/_2$% silicon alloy had a tensile strength of about 88,000 lbs./in.,^{2} with an elongation of 13.5%. An alloy with 3% silicon can be rolled with a reduction of 50% to give a tensile strength of 110,000 lbs./in.^{2}, with an elongation of 10%. In the cast state the alloy containing 3$^1/_2$% silicon and 1% manganese had about the best mechanical properties—tensile 49,400 lbs./in.^{2}—elongation 25%. Corrosion tests and oxidation tests indicated that the silicon alloys were slightly better than the more common alloys. The straight silicon alloys have mechanical properties practically equivalent to the ternary alloys, and there is no marked difference in corrosion resistance. Contains 10 references. JLG(2)

Physical and Chemical Properties of (Stellite) Cobalt-Chrome-Tungsten Alloys. (Ueber die physikalischen und chemischen Eigenschaften der Legierung auf der Grundlage Kobalt-Chrom-Wolfram.) K. Löbbecke. *Mitteilungen Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 1, No. 3 (1929) pages 65–82. 11 references.

Investigations were made to find which of the 3 metals, Cobalt, Chromium and Tungsten, and the Carbon affects the structure, hardness, resistance to wear and corrosion resistance of Stellite. The influence of different heat treatments was also investigated. From the structures of the alloys, it can be seen that the graphite is prominent in alloys high in carbon and after certain heat treatment. By holding the carbon constant, about 2.5% and varying the Cobalt and Chromium contents, it has been found that small amount of Cobalt produces the highest hardness, and small amounts of Chromium the lowest. Tungsten does not influence the hardness to any extent. By increasing the carbon content to about 3.2% the hardness increases sharply and with further increase in carbon, the hardness decreases until with carbon more than 4% then the hardness remains constant. This constant hardness is increased by proper heat treatment. It is possible to increase the hardness of Stellite from 250 to 650 Brinell. With increase in carbon the resistance to wear is reduced. Chromium has no influence on resistance to wear. It was found that an alloy containing 55% Cobalt, 28% Chromium, 15% Tungsten, 2% Carbon is the best resistant to corrosion of this type alloy (Stellite). GTM(2)

Physical Properties and Age Hardening of Beryllium-Copper Alloys. (Technische Eigenschaften und Vergütung von Beryllium-Kupfer-legierungen.) G. Masing & O. Dahl. *Wissenschaftliche Veröffentlichungen des Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 101–125.

Be-Cu alloys when quenched from above 800° undergo age-hardening at 250–400° if the Be exceeds 1%. The maximum hardness of 510 is obtained in 1 hour with the alloy containing 4% Be by aging at 350°; higher or lower temperatures or more prolonged heating give lower hardness values, but once hardened, the alloys remain unchanged at 250° for more than 100 days. The electrical conductivity of the 2.5% Be alloys increases in a smooth curve concave to the time axis over a period of 25 hours at 350°, whereas the hardness reaches a maximum in 1$^1/_2$ hours and then commences to decrease slowly; after 3 hours at 350° the alloy has a tensile strength of 135 kg./mm.^{2}, a yield point of 125 kg./mm.^{2} and an elongation of 0.8%, the corresponding values for the quenched alloy being 48.9 kg./mm.^{2}, 15.7 kg./mm.^{2} and 52%. Similar results may be obtained by the heat treatment of sand- and chill-castings of alloys containing 2–3% Be. The corrosion-resisting power of Be-Cu alloys is greater than that of 12–14% Zn bronzes and about equal to that of 6–8% Al bronzes; after age-hardening the resistance to attack by HCl is appreciably reduced. 9 references. (2)

The Brinell Hardness of Platinum Alloys. (Die Brinellhärte von Platinlegierungen.) *Deutsche Goldschmiede-Zeitung*, Vol. 33, April 5, 1930, pages 165–168.

The Brinell hardnesses of commercially important platinum and palladium alloys, both as rolled and as annealed, are given. Some of the values are:

100% Pt		97	47
70% Pt	30% Ir	400	310
90% Pt	10% Pd	160	85
75% Pt	25% Pd	175	100
25% Pt	75% Pd	155	80
90% Pd	10% Au	124	95
50% Pd	50% Au	186	98
10% Pd	90% Au	120	70
90% Pd	10% Ag	130	74
80% Pd	20% Ag	294	248
40% Pd	60% Ag	130	88
10% Pd	90% Ag	95	53

Iridium is a more powerful hardener of platinum than rhodium; 20% Ir producing the same hardness as 50% Rh. JLG(2)

PROPERTIES OF FERROUS ALLOYS (3)

Gray Iron Possesses Valuable Engineering Properties. Part. 3. *Foundry*, Vol. 58, April 1, 1930, pages 111–115.

Since composition of gray iron varies the alloys are classified into various groups. C and Si are the most important elements from engineering viewpoint. Gives a table of classification according to Si and C content. Strength varies inversely with the % of Si and C. Degree of graphitization is influenced by the cooling of the greater proportion of pearlite compared to graphite. Cooling rate increase hinders graphitization and increase of Si promotes it. Excess of Si will cause some of pearlite to break down forming weak ferrite and more graphite. Slow cooling causes larger grain size. In making tensile tests on gray iron the practice is to machine test bars from a cast test piece. This represents the center of the section and is the weakest portion. Ultimate tensile tests range from 20,000 lbs./in.^{2} for low to 60,000 lbs./in.^{2} for high grade castings. Explains stress and strain diagram. Contains numerous tables and diagrams. VSP(3)

High Test Cast Iron. R. Moldenke. *Mechanical Engineering*, Vol. 52, June 1930, pages 593–595.

The article gives a general review on high test cast iron, with reference to the effect of superheating, distribution and size of graphite, heat treatment of cast iron. GN(3)

Foundry Products (Giessereierzeugnisse). H. Bator. *Krupp'sche Monatshefte*, Vol. 11, June 1930, pages 173–176.

The most specialized production of foundry products, among which chilled castings play an important role, is considered. The properties of the products are briefly reviewed. GN(3)

Cast-Iron Castings of High-Silicon Content. *Foundry Trade Journal*, Vol. 42, Mar. 27, 1930, page 240.

Gives a classification for cast irons containing from 5 to 19% Si. They resist corrosion by hot or cold diluted H_2SO_4 and HNO_3, as well as cold diluted HCl. Silicon irons can be melted in cupola up to 10%, and even up to 18% Si. Molding should be carried out in a permeable sand. Up to 10% Si, these irons can be machined; above that they can only be worked by grinding. Gives composition of charges. VSP(3)

Permanence. *Metallurgist*, Nov. 1929, pages 161–162.

Editorial on the permanence of heat-treated alloy steels from the point of view of the engineer, with special reference to nickel-chromium steels. (3)

High-Manganese Steels. (L'acier à haute teneur en manganèse.) Marcel Guedras. *Aciers speciaux, Métaux et Alliages*, Vol. 4, July 1929, pages 332–338.

The author discusses the characteristics of high-Mn steels, their fabrication, composition of the metal, shrinkage of the cast metal, heat treatment, applications and machining. (3)

Molybdenum. (Le Molybdene.) R. Cazaud. *Aciers speciaux, Métaux et Alliages*, Vol. 4, Sept. 1929, pages 413–416; Oct. 1929, pages 465–469; Nov. 1929, pages 518–524; Dec. 1929, pages 590–597.

A review of the general properties of Mo steel. The author discusses the use of special Mo steels in airplane construction and gives a bibliography. He also deals with its use in automotive work, railways and machine construction. An analysis is given. (3)

Screw Stock. Proposed revision of A.S.T.M. specifications A 107-27 and A 108-27, *Preprint* 9, *Report of American Society for Testing Materials Committee A-1 on Steel*, June 1930 Meeting.

The sulphur limits for Bessemer screw stock are proposed to be changed from 0.075–0.15% to 0.10–0.18% S. HWG(3)

Chromium-Manganese Steels. F. M. BECKET. *Preprint*, May 1930 Meeting, *American Iron & Steel Institute*, 15 pages; *Engineering*, Vol. 129, June 6, 1930, page 149; *Iron Age*, Vol. 125, May 15, 1930, pages 1468–1470; *Blast Furnace & Steel Plant*, Vol. 18, June 1930, pages 956–961; *Metallurgist*, July 1930, pages 106–107.

A study of stainless Cr-Mn steels of good deep-drawing qualities. With about 18% Cr, additions of 8–20% Mn produce desirable deep-drawing and impact properties. As in plain Cr and Ni Cr steels, 20% Cr or over gives best results for long-time exposure to high temperatures. For atmospheric corrosion the low carbon Cr-Mn steels with over 16% Cr in the quenched and air-cooled conditions. At 900° C. the attack of concentrated moist SO_2 is much greater on the 18% Cr 8% Ni than on the 18% Cr 8% Mn. The structure of the low carbon Cr-Mn steel is not wholly austenitic. With higher carbon and sufficient Mn, they are wholly austenitic. Addition of W or Co very materially increases the high-temperature strength, in short-time tests, of the 18% Cr 8% Mn steel. One steel with 0.18% C, 0.21% Si, 18.50% Cr, 8.80% Mn and 4.97% Co, air-cooled from 1050° C., had tensile strengths of 50,000 and 19,000 lbs./in.^{2} at 600° and 900° C. respectively. In many corroding media the addition of $^1/_2$–3% Cu to the 18% Cr 8% Mn steel proves advantageous, but a combination of very high Cu and very high Mn produces red shortness. The Cr-Mn steels are especially attractive from the steel maker's point of view, there is less difficulty in producing sound, clean, ingots than in other high Cr steels. They roll well, can be made into seamless tubing, weld well and are easily polished. The properties of the steels discussed are given in curves and tables. VVK+VSP+HWG(3)

Open-Hearth Iron Plates of Flange Quality. Proposed tentative specification in *Preprint* 9, *Report of American Society for Testing Materials Committee A-1 on Steel*, June 1930 Meeting, 4 pages.

Three types of basic open-hearth flange steel are admitted. In all, S is limited to 0.04% and P to 0.015%. In one (ingot iron) the sum of C, Mn, Si, S and P is not to exceed 0.10%. In the others (copper-bearing) this sum may amount to 0.25%. In one of them 0.20% Cu is required in the other 0.40% Cu and 0.05% Mo. The mechanical properties for all 3 are the same, 44,000 lbs./in.^{2} tensile and 27,500 yield by drop of beam, with 25% elongation in 8″. Lower elongation is permitted in plates thicker than $^3/_4$″ or thinner than $^5/_{16}$″. Cold bend requirements are, flat on itself for 1″ or under, or 180° around a pin equal in diameter to the thickness, for thicker plates. Weight limitations are given for plates ordered to thickness. HWG(3)

Some Effects of Nickel Content in Austenitic Iron-Chromium-Nickel Alloys. N. B. PILLING. *Preprint* 36, June 1930 Meeting, *American Society for Testing Materials*, 13 pages; *Engineering*, Vol. 130, Aug. 29, 1930, 280-281.

The austenitic 18% Cr 8% Ni alloy with around 0.1% C, so much used and so much discussed at present, is not in an entirely stable austenitic condition. On cold-working it hardens rapidly and its magnetic permeability increases, and α-iron is precipitated. On heating to sufficiently high temperatures, especially with concomitant deformation, carbide precipitation occurs, and embrittlement may result. This unstability, while affected by carbon content, is primarily due to the composition of the steel. If, holding the Cr at 18%, the Ni is raised to about 14% the unstable margin is passed and, with any reasonable carbon content, the alloy remains austenitic no matter what mechanical treatment or heat treatment is given it. The cost of the extra nickel is balanced by the less stringent requirement for low carbon content of the ferro-chromium used in making the steel. The 18–14 alloy does not harden as rapidly on cold working as the 18–8. The corrosion resistance to air saturated with dilute H_2SO_4 is better than with 18–8. Diagrams and tables are given showing the properties of alloys with various Cr and Ni contents. LM+HWG(3)

An Investigation of Some of the Physical Properties of the Iron, Nickel, Chromium System. W. A. DEAN. (Rensselaer Polytechnic Institute), *Engineering & Science Series*, No. 26, June 1930, pages 31–55.

The hardness, electrical resistance, thermal expansion, magnetostrictive characteristics, X-ray crystal structure and resistance to oxidation at 1000° C. of 26 alloys. The alloys were made from electrolytic Fe, Ni and Cr with 0.4% Al added as degasifier. Heating for 20 hours, brushing off the oxidation products with a stiff wire brush and weighing was tried. Alloys which formed pervious oxide coatings would be broken down in four 20 hr. heating periods, while those that are useful for high-temperature service lose not over 0.1 gram/cm.^{2} in 20 such periods. Using this criterion and that of ability to be forged and cold rolled, it was concluded that alloys having Fe:Cr ratios of 80:20–60:40 with up to 55% Ni are less expensive than many of those in use for high temperature service, but equally useful to resist oxidation at high temperatures. High temperature strength, either short-time or creep, tests were not made. A ternary diagram shows the regions in which the alloys are face centered like Ni, and body centered, like Fe and Cr. Between these regions is one where both structures coexist. This region begins when the Ni lattice has been stretched to about 3.56 A. U. At around 75–80% Cr, there were signs of a third, undetermined lattice. A duplex X-ray structure corresponds to a hard alloy, not readily fabricated. The alloy with the highest temperature coefficient of expansion was 60 Fe, 20 Ni, 20 Cr. Magnetostrictive alloys are confined to those of the Fe Ni and Fe Cr series with not over 10% of the third element present. HWG(3)

Carburizing Steels. *Vancoram Review*, Vol. 1, Oct. 1930, pages 145–148.

Brief article lists properties desired in a carburized alloy steel for heavy duty. Physical properties given. (3)

Contribution to the Knowledge of Silicon Structural Steels. (Beiträge zur Kenntnis des Siliziumbaustahles.) H. BUCHHOLTZ. *Mitteilungen Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 1, No. 5 (1929) pages 103–145, 49 references.

A comparative study of silicon structural steels and plain carbon steel. The tensile properties of the silicon structural steel particularly the elastic limit, are limited by the rolling conditions and by the rolling temperature. GTM(3)

What Is the Maximum Life of Cast Iron Pipe? B. B. HODGMAN. (National Water Main Cleaning Co.) *Water Works Engineering*, Vol. 83, July 30, 1930, pages 1141–1142.

The article considers the old cast iron pipe line build by Louis XIV at Versailles, France, still in operation and estimates the maximum life of cast iron pipe at 500 years and more. GN(3)

Relation between Hardness and Magnetic Properties of Alloys. (Ueber den Zusammenhang zwischen Härte und magnetischen Eigenschaften von Legierungen.) A. KUSSMANN & B. SCHARNOW. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Sept. 21, 1929, page 1360.

Three factors influence the hardness of metals and alloys: 1. Constitution, particularly formation of solid solutions, and alloys; 2. Plastic deformation; 3. Other phenomena as for example hardening of steel or refining which are based on a transformation due to a heat treatment. Tests were made with several series of solid solutions; Fe-Al, Fe-Cr, Ni-Cu, Ni-Fe and several heterogeneous mixtures. In some cases it was shown that a determination of hardness can be made by determining the coercive force in magnetic materials. A real regularity in the relation has, however, not been observed. Ha(3)

Molybdenum-steel. (Molybdänstahl.) *Zeitschrift*
genieure, Vol. 74, Feb. (1, 1930, page 158.

In 1920, 250,000 tons of molybdenum-steel were pro
parts requiring high qualities and reliability due to thei
composition of 3 different steels with their mechanical b

High-grade Steels for Large Structures. (Hochwer
den Grossstahlbau.) E. H. SCHULZ & H. BUCHHOLTZ.
deutscher Ingenieure, Vol. 73, Nov. 2, 1929, pages 1573–

First a review is given of the physical and mechanica
tural steels as they were used up to a few years ago for
bridges, large buildings and ships. A table shows that
strength of 37 to 44 kg/mm.^{2} with an elongation of 22
bending strength of 18 kg./mm.^{2} was considered satisfact
since that time, however, produced steels of much bette
1928 the "Union Baustahl" was made with a tensile st
kg./mm.^{2} and elongation of 37% and a vibration streng
A similar steel of same tensile strength was produced in
1915, a high-silicon steel. In recent times certain claims
aging must also be met. Diagram and tables illustrate
ferences.

Heat Treatment Determines Properties of Mangane
P. EVANS. *Foundry*, Vol. 58, Sept. 1, 1930, pages 102–1

For casting purposes high Mn steel of austenitic type
and 1.00 to 1.4% C, and the low Mn steel of pearlitic ty
Mn and 0.25 to 0.50% C are used. Explains mechanism
properties on that type of steel. Low Mn steel if proper
physical properties comparable to more complex alloy stee
treatment.

Physical Properties and Structure of Drawn Steel W
of the Preceeding Heat Treatment. (Festigkeitseigen
fügeausbildung von gezogenem Stahldraht in Abhängigkeit
gangenen Wärmebehandlung.) A. POMP & A. LINDEBERG
Kaiser Wilhelm Institut für Eisenforschung, Vol. 12,
pages 39–64, 12 references.

Steel wire 0.60% C was patented in a continuous labor
different temperatures in various media (air, lead, oil w
pering). Samples were drawn in 11 drafts with a total r
92%. The material was tested as received and after ea
bending and elastic properties. The structure was exami
temperatures, low lead temperatures and moderate redu
are most favorable.

Single Potential of Iron and Steel Electrodes. H. E
ZAWA. *Kinzoku no Kenkyu*, Sept. 1930, pages 473–486.

Single crystals of iron, Armco iron and electrolytic i
vacuum furnace were used as electrodes; a great care wa
the occluded hydrogen gas in the electrodes and the
−0.693 V and −0.691 V were obtained respectively. Eff
surface condition and occluded hydrogen gas on the electr
studied and it was found that the rougher the surface of
greater the value of single potential; and a small differen
polishing of electrode surface does not, however, affect
but only affects the speed of the reaction occurring bet
electrolyte. Occluded hydrogen gas causes an increase in
potentials of annealed steel electrodes of carbon content
0.1–1.4% were studied and concluded that the final va
potential for different steels increases at first with inc
carbon, reaching a maximum at 0.9% carbon and then
further increase of carbon content. Potential difference
trodes of annealed and globularised eutectoid carbon s
measured. When the structure of the globularized specim
the pearlitic steel, the former is more electropositive than
the case of the coarsely globularised specimen, the potentia
opposite sign. These opposite results can be explained
the structure. Effect of grain boundary in the electrode
potential was studied and it was found that the electrode
grains is more electronegative than that consisting of small
be concluded that grain boundary acts more or less to r
potential. In order to find the effect of small strain on
tential, a large single crystal was gently sawed by hand int
one of them was strained by 1 Kg. load, their potentia
differentially. The strained electrode was more electro
other. When the load was taken off, the potential diffe
appeared.

Change in Electric Resistance Produced in Cold-W
Annealing. K. TAKAHASHI. *Science Reports of Tohok*
versity, Japan, Series I (1930) pages 265–282.

The increase of electric resistance due to cold-working
opposite effects. The distance of atoms is increased by cold
number of free electrons, which may stray off from its own at
minishes and electric resistance is thus increased. But fibe
duced by cold-working has fewer grain boundaries in the
working than in other directions, and this produces a decrea
tance. Insoluble impurities which have been segregated in
crystal boundaries and have prevented the flow of electricity
cold-working and consequently diminish the electric resis
electric resistance first increases and reaches a maximum, as
working increases, and afterward begins to decrease. In th
maximum is at about 50% reduction. In annealing col
rapid decrease of resistance is observed at such a low temper
where no recrystallization has occurred. This is due to the
stress caused by the cold-working; because this release c
crease of density, and, therefore, results in an increase of t
annealed at higher temperatures, metals begin to recry
pseudo-fibrous structure which on further heating, chang
gonal structure. Such a change of structure increases el
Thus resistance-annealing curves have a minimum point
perature.

CORROSION, EROSION, OXIDATION, PAS
PROTECTION OF METALS & ALLOY

Contribution to the Morphology of Rust. (Beitrag zur
Rostes.) F. DREXLER. (I. G. Farbenindustrie A. G.
Metallschutz, Vol. 6, Jan. 1930, pages 3–7.

An X-ray study (powder method, Fe-K radiation) was m
sheets which were allowed to rust in various media. The
some X-ray photograms are included in the paper which
clusion: Besides Fe-hydroxide-gel only α-and γ-FeOOH
ultimate products of the rust process. As nuclei for the f
dust-like particles as salts, cinder or soot particles etc. are
formation of the α and γ-FeOOH seems to depend on the ch
the nucleous substance. The physical structure of the rus
the modification of the compound FeOOH while the colo
on the size of the individual crystal. Electrolytic reaction
decomposition of iron.

ecent Developments in Light Aluminum Alloys. (**Les Recents Progres Alliages Legers d'Aluminium.**) Leon Guillet. *Genie Civil*, Vol. 96, y 3, 1930, pages 427–431; May 10, 1930, pages 449–454; May 17, 1930, es 475–478.

iscusses the history of aluminum alloys as a supplement to the review de by this same magazine in 1924. Takes up those alloys containing 80– % Al. Important articles and investigations dealing with the alloys are marized. Their physical characteristics and chemical properties, their chanical treatment and heat-treatment and their industrial utilization are cussed. (2)

eryllium-Nickel Alloys. (**Beryllium-Nickellegierungen.**) G. Masing O. Dahl. *Wissenschaftliche Veröffentlichungen aus dem Siemens-nzern*, Vol 8, No. 1 (1929) pages 211–219.

eryllium dissolves in molten Ni with the evolution of much heat; the tem contains one compound, NiBe, which forms a eutectic with nickel, lting at 1155° containing 5.2% Be. The saturated solid solution of Be in contains 2.8% Be at the eutectic temperature and 1.4% at 800°. Alloys taining more than 1.5% Be undergo age-hardening after quenching from 0°, a maximum hardness of 550 being obtained with the 3% alloy in 1 hour 600°, but hardness values of over 600 can be obtained with the 2.5 and % Be alloys by prolonged annealing at 450°. These alloys after heat atment have a tensile strength of 132 kg./mm.^{2} (187,500 lbs./in.^{2}) with an stic limit of 110 kg./mm.^{2} (156,200 lbs./in.^{2}); they are almost as resistant pure Ni to corrosion by dilute HNO_3 and HCl and are quite unattacked by water. (2)

he Properties of Pressed Bars of Electrolytic Copper, Reverberatory pper, Arseniferous Copper, Aluminum Bronze with 4% Aluminum in pendence on the Conditions of Pressing. (**Ueber die Eigenschaften Presstangen aus Elektrolytkupfer, Hüttenkupfer, arsenlegiertem pfer, Aluminiumbronze mit 4% Aluminium in Abhängigkeit von den essbedingungen.**) P. Siebe & G. Elsner (Experimental Station of nabrücker Kupfer- und Drahtwerk). *Zeitschrift für Metallkunde*, l. 22, June 1930, pages 203–206; July 1930, pages 238–245, 7 references.

n investigation was carried out with electrolytic Cu, Cu refined in the erberatory furnace, Cu containing As and 4% Al, respectively, to study influence of temperature during pressing operation and annealing upon sile strength at room and at elevated temperature, impact hardness and in size. The samples were pressed at the lowest and highest possible nperatures. It was noticed in the As delivered bars that a low pressing nperature results in an increase of tensile strength and elongation whereas luction of area generally decreases. At higher annealing temperature the s in physical properties in the cold pressed material is more pronounced. is is ascribed to the larger grain growth in the bars pressed at lower nperature. The examination being extended over the whole length of the rs, disclosed that the influence of the low pressing temperature became re pronounced toward the end of the test pieces. By cold drawing, the ength of the material drawn at lower temperatures yielded larger gains ile the reduction in area is decreased which, however, remains constant if gher temperatures are applied. Former observations made on MS 58 rass with 58% Cu), concerning the influence of annealing temperature on in size, are confirmed. EF(2)

Investigation of the Thermal Conductivity of the System Copper–Nickel. F. Sager. Ph.D. Thesis. *Rensselaer Polytechnic Institute, Engineering d Science Series* No. 27, June 1930, 48 pages.

Alloys made up for 80:20, 60:40, 40:60 and 20:80 Cu and Ni were made by elting Mond Ni and Cu cable, deoxidizing with 0.20% Mn and 0.17% Mg. and Ni were also included. No analyses of the alloys are given. By a ynamic" method involving the velocity with which a cyclic temperature riations progressed along a wire specimen, the thermal conductivity was idied up to about 700° C.

Thermal conductivities measured for the lowest and highest temperatures idied are as follows:

aterial Cu-Ni	Temp. ° C.	Thermal Cond. cal./cm./sec./° C.	Elect. Cond. mhos./cm. × 10^5
0 ..	29	0.99	5.55
	497	0.93	1.99
0 20	48	0.089	0.354
	711	0.223	0.302
0 40	62	0.060	0.199
	717	0.218	0.192
0 60	52	0.058	0.188
	697	0.160	0.174
0 80	44	0.086	0.336
	693	0.203	0.196
. 100	54	0.193	0.960
	743	0.278	0.232

The thermal conductivities are in general higher than those of other in-stigators. The author states that the method used probably gives high sults especially at the higher temperatures.

The Lorenz ratio, that of thermal to electrical conductivity, is discussed. Specific heat was determined calorimetrically. The average specific heats e given by the following equations.

Ni below magnetic transformation $S = 0.0985 + 0.0000666\ t$
Ni above magnetic transformation $S = 0.1185 + 0.0000093\ t$
80 Ni 20 Cu $S = 0.1099 + 0.000010\ t$
60 Ni 40 Cu $S = 0.1029 + 0.000010\ t$
40 Ni 60 Cu $S = 0.0987 + 0.000013\ t$
20 Ni 80 Cu $S = 0.0911 + 0.000019\ t$
Cu $S = 0.0959 + 0.0000045\ t$

The true specific heats are also given. Observations were made up to 0° or 800° C. The precision of the specific heat determinations is not scussed. HWG(2)

Silicon-Copper Alloys and Silicon-Manganese-Copper Alloys. E. Voce ritish Non-Ferrous Metals Research Association). *Institute of Metals, dvance Copy* No. 543 (1930) 31 pages.

The mechanical and physical properties of both cast and worked alloys ere studied. Alloys up to 1% silicon were drawn into 0.050" wire without fficulty. The electrical conductivity of these cold drawn wires decreases pidly with increasing silicon while the strength increased. The cast and lled alloys had properties similar to ordinary bronze. Machining proper-es are improved as silicon increases. Silicon-copper alloys containing up to /$_2$% silicon can be hot rolled easily. The hot rolled 4$^1/_2$% silicon alloy had tensile strength of about 88,000 lbs./in.,^{2} with an elongation of 13.5%. n alloy with 3% silicon can be rolled with a reduction of 50% to give a nsile strength of 110,000 lbs./in.^{2}, with an elongation of 10%. In the cast ate the alloy containing 3$^1/_2$% silicon and 1% manganese had about the est mechanical properties—tensile 49,400 lbs./in.^{2}—elongation 25%. Cor-osion tests and oxidation tests indicated that the silicon alloys were slightly etter than the more common alloys. The straight silicon alloys have echanical properties practically equivalent to the ternary alloys, and there no marked difference in corrosion resistance. Contains 10 references. JLG(2)

Physical and Chemical Properties of (Stellite) Cobalt-Chrome-Tungsten Alloys. (**Ueber die physikalischen und chemischen Eigenschaften der Legierung auf der Grundlage Kobalt-Chrom-Wolfram.**) K. Löbbecke. *Mitteilungen Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 1, No. 3 (1929) pages 65–82. 11 references.

Investigations were made to find which of the 3 metals, Cobalt, Chromium and Tungsten, and the Carbon affects the structure, hardness, resistance to wear and corrosion resistance of Stellite. The influence of different heat treatments was also investigated. From the structures of the alloys, it can be seen that the graphite is prominent in alloys high in carbon and after certain heat treatment. By holding the carbon constant, about 2.5% and varying the Cobalt and Chromium contents, it has been found that small amount of Cobalt produces the highest hardness, and small amounts of Chromium the lowest. Tungsten does not influence the hardness to any extent. By increasing the carbon content to about 3.2% the hardness increases sharply and with further increase in carbon, the hardness decreases until with carbon more than 4% then the hardness remains constant. This constant hardness is increased by proper heat treatment. It is possible to increase the hardness of Stellite from 250 to 650 Brinell. With increase in carbon the resistance to wear is reduced. Chromium has no influence on resistance to wear. It was found that an alloy containing 55% Cobalt, 28% Chromium, 15% Tungsten, 2% Carbon is the best resistant to corrosion of this type alloy (Stellite). GTM(2)

Physical Properties and Age Hardening of Beryllium-Copper Alloys. (**Technische Eigenschaften und Vergütung von Beryllium-Kupfer-legierungen.**) G. Masing & O. Dahl. *Wissenschaftliche Veröffentlichungen des Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 101–125.

Be-Cu alloys when quenched from above 800° undergo age-hardening at 250–400° if the Be exceeds 1%. The maximum hardness of 510 is obtained in 1 hour with the alloy containing 4% Be by aging at 350°; higher or lower temperatures or more prolonged heating give lower hardness values, but once hardened, the alloys remain unchanged at 250° for more than 100 days. The electrical conductivity of the 2.5% Be alloys increases in a smooth curve concave to the time axis over a period of 25 hours at 350°, whereas the hardness reaches a maximum in 1$^1/_2$ hours and then commences to decrease slowly; after 3 hours at 350° the alloy has a tensile strength of 135 kg./mm.^{2}, a yield point of 125 kg./mm.^{2} and an elongation of 0.8%, the corresponding values for the quenched alloy being 48.9 kg./mm.^{2}, 15.7 kg./mm.^{2} and 52%. Similar results may be obtained by the heat treatment of sand- and chill-castings of alloys containing 2–3% Be. The corrosion-resisting power of Be-Cu alloys is greater than that of 12–14% Zn bronzes and about equal to that of 6–8% Al bronzes; after age-hardening the resistance to attack by HCl is appreciably reduced. 9 references. (2)

The Brinell Hardness of Platinum Alloys. (**Die Brinellhärte von Platinlegierungen.**) *Deutsche Goldschmiede-Zeitung*, Vol. 33, April 5, 1930, pages 165–168.

The Brinell hardnesses of commercially important platinum and palladium alloys, both as rolled and as annealed, are given. Some of the values are:

100% Pt		97	47
70% Pt	30% Ir	400	310
90% Pt	10% Pd	160	85
75% Pt	25% Pd	175	100
25% Pt	75% Pd	155	80
90% Pd	10% Au	124	95
50% Pd	50% Au	186	98
10% Pd	90% Au	120	70
90% Pd	10% Ag	130	74
80% Pd	20% Ag	294	248
40% Pd	60% Ag	130	88
10% Pd	90% Ag	95	53

Iridium is a more powerful hardener of platinum than rhodium; 20% Ir producing the same hardness as 50% Rh. JLG(2)

PROPERTIES OF FERROUS ALLOYS (3)

Gray Iron Possesses Valuable Engineering Properties. Part. 3. *Foundry*, Vol. 58, April 1, 1930, pages 111–115.

Since composition of gray iron varies the alloys are classified into various groups. C and Si are the most important elements from engineering viewpoint. Gives a table of classification according to Si and C content. Strength varies inversely with the % of Si and C. Degree of graphitization is influenced by the cooling of the greater proportion of pearlite compared to graphite. Cooling rate increase hinders graphitization and increase of Si promotes it. Excess of Si will cause some of pearlite to break down forming weak ferrite and more graphite. Slow cooling causes larger grain size. In making tensile tests on gray iron the practice is to machine test bars from a cast test piece. This represents the center of the section and is the weakest portion. Ultimate tensile tests range from 20,000 lbs./in.^{2} for low to 60,000 lbs./in.^{2} for high grade castings. Explains stress and strain diagram. Contains numerous tables and diagrams. VSP(3)

High Test Cast Iron. R. Moldenke. *Mechanical Engineering*, Vol. 52, June 1930, pages 593–595.

The article gives a general review on high test cast iron, with reference to the effect of superheating, distribution and size of graphite, heat treatment of cast iron. GN(3)

Foundry Products (**Giessereierzeugnisse**). H. Bator. *Krupp'sche Monatshefte*, Vol. 11, June 1930, pages 173–176.

The most specialized production of foundry products, among which chilled castings play an important role, is considered. The properties of the products are briefly reviewed. GN(3)

Cast-Iron Castings of High-Silicon Content. *Foundry Trade Journal*, Vol. 42, Mar. 27, 1930, page 240.

Gives a classification for cast irons containing from 5 to 19% Si. They resist corrosion by hot or cold diluted H_2SO_4 and HNO_3, as well as cold diluted HCl. Silicon irons can be melted in cupola up to 10%, and even up to 18% Si. Molding should be carried out in a permeable sand. Up to 10% Si, these irons can be machined; above that they can only be worked by grinding. Gives composition of charges. VSP(3)

Permanence. *Metallurgist*, Nov. 1929, pages 161–162.

Editorial on the permanence of heat-treated alloy steels from the point of view of the engineer, with special reference to nickel-chromium steels. (3)

High-Manganese Steels. (**L'acier à haute teneur en manganèse.**) Marcel Guedras. *Aciers speciaux, Mêtaux et Alliages*, Vol. 4, July 1929, pages 332–338.

The author discusses the characteristics of high-Mn steels, their fabrication, composition of the metal, shrinkage of the cast metal, heat treatment, applications and machining. (3)

Molybdenum. (**Le Molybdene.**) R. Cazaud. *Aciers speciaux, Mêtaux et Alliages*, Vol. 4, Sept. 1929, pages 413–416; Oct. 1929, pages 465–469; Nov. 1929, pages 518–524; Dec. 1929, pages 590–597.

A review of the general properties of Mo steel. The author discusses the use of special Mo steels in airplane construction and gives a bibliography. He also deals with its use in automotive work, railways and machine construction. An analysis is given. (3)

Screw Stock. Proposed revision of A.S.T.M. specifications A 107-27 and A 108-27, *Preprint* 9, *Report of American Society for Testing Materials Committee A*-1 *on Steel*, June 1930 Meeting.

The sulphur limits for Bessemer screw stock are proposed to be changed from 0.075–0.15% to 0.10–0.18% S. HWG(3)

Chromium-Manganese Steels. F. M. Becket. *Preprint*, May 1930 Meeting, *American Iron & Steel Institute*, 15 pages; *Engineering*, Vol. 129, June 6, 1930, page 149; *Iron Age*, Vol. 125, May 15, 1930, pages 1468–1470; *Blast Furnace & Steel Plant*, Vol. 18, June 1930, pages 956–961; *Metallurgist*, July 1930, pages 106–107.

A study of stainless Cr-Mn steels of good deep-drawing qualities. With about 18% Cr, additions of 8–20% Mn produce desirable deep-drawing and impact properties. As in plain Cr and Ni Cr steels, 20% Cr or over gives best results for long-time exposure to high temperatures. For atmospheric corrosion the low carbon Cr-Mn steels with over 16% Cr in the quenched and air-cooled conditions. At 900° C. the attack of concentrated moist SO_2 is much greater on the 18% Cr 8% Ni than on the 18% Cr 8% Mn. The structure of the low carbon Cr-Mn steel is not wholly austenitic. With higher carbon and sufficient Mn, they are wholly austenitic. Addition of W or Co very materially increases the high-temperature strength, in short-time tests, of the 18% Cr 8% Mn steel. One steel with 0.18% C, 0.21% Si, 18.50% Cr, 8.80% Mn and 4.97% Co, air-cooled from 1050° C., had tensile strengths of 50,000 and 19,000 lbs./in.^{2} at 600° and 900° C. respectively. In many corroding media the addition of $^1/_2$–3% Cu to the 18% Cr 8% Mn steel proves advantageous, but a combination of very high Cu and very high Mn produces red shortness. The Cr-Mn steels are especially attractive from the steel maker's point of view, there is less difficulty in producing sound, clean, ingots than in other high Cr steels. They roll well, can be made into seamless tubing, weld well and are easily polished. The properties of the steels discussed are given in curves and tables. VVK+VSP+HWG(3)

Open-Hearth Iron Plates of Flange Quality. Proposed tentative specification in *Preprint* 9, *Report of American Society for Testing Materials Committee A*-1 *on Steel*, June 1930 Meeting, 4 pages.

Three types of basic open-hearth flange steel are admitted. In all, S is limited to 0.04% and P to 0.015%. In one (ingot iron) the sum of C, Mn, Si, S and P is not to exceed 0.10%. In the others (copper-bearing) this sum may amount to 0.25%. In one of them 0.20% Cu is required in the other 0.40% Cu and 0.05% Mo. The mechanical properties for all 3 are the same, 44,000 lbs./in.^{2} tensile and 27,500 yield by drop of beam, with 25% elongation in 8″. Lower elongation is permitted in plates thicker than $^3/_4$″ or thinner than $^5/_{16}$″. Cold bend requirements are, flat on itself for 1″ or under, or 180° around a pin equal in diameter to the thickness, for thicker plates. Weight limitations are given for plates ordered to thickness. HWG(3)

Some Effects of Nickel Content in Austenitic Iron-Chromium-Nickel Alloys. N. B. Pilling. *Preprint* 36, June 1930 Meeting, *American Society for Testing Materials*, 13 pages; *Engineering*, Vol. 130, Aug. 29, 1930, 280-281.

The austenitic 18% Cr 8% Ni alloy with around 0.1% C, so much used and so much discussed at present, is not in an entirely stable austenitic condition. On cold-working it hardens rapidly and its magnetic permeability increases, and α-iron is precipitated. On heating to sufficiently high temperatures, especially with concomitant deformation, carbide precipitation occurs, and embrittlement may result. This unstability, while affected by carbon content, is primarily due to the composition of the steel. If, holding the Cr at 18%, the Ni is raised to about 14% the unstable margin is passed and, with any reasonable carbon content, the alloy remains austenitic no matter what mechanical treatment or heat treatment is given it. The cost of the extra nickel is balanced by the less stringent requirement for low carbon content of the ferro-chromium used in making the steel. The 18–14 alloy does not harden as rapidly on cold working as the 18–8. The corrosion resistance to air saturated with dilute H_2SO_4 is better than with 18–8. Diagrams and tables are given showing the properties of alloys with various Cr and Ni contents. LM+HWG(3)

An Investigation of Some of the Physical Properties of the Iron, Nickel, Chromium System. W. A. Dean. (Rensselaer Polytechnic Institute), *Engineering & Science Series*, No. 26, June 1930, pages 31–55.

The hardness, electrical resistance, thermal expansion, magnetostrictive characteristics, X-ray crystal structure and resistance to oxidation at 1000° C. of 26 alloys. The alloys were made from electrolytic Fe, Ni and Cr with 0.4% Al added as degasifier. Heating for 20 hours, brushing off the oxidation products with a stiff wire brush and weighing was tried. Alloys which formed pervious oxide coatings would be broken down in four 20 hr. heating periods, while those that are useful for high-temperature service lose not over 0.1 gram/cm.^{2} in 20 such periods. Using this criterion and that of ability to be forged and cold rolled, it was concluded that alloys having Fe:Cr ratios of 80:20–60:40 with up to 55% Ni are less expensive than many of those in use for high temperature service, but equally useful to resist oxidation at high temperatures. High temperature strength, either short-time or creep, tests were not made. A ternary diagram shows the regions in which the alloys are face centered like Ni, and body centered, like Fe and Cr. Between these regions is one where both structures coexist. This region begins when the Ni lattice has been stretched to about 3.56 A. U. At around 75–80% Cr, there were signs of a third, undetermined lattice. A duplex X-ray structure corresponds to a hard alloy, not readily fabricated. The alloy with the highest temperature coefficient of expansion was 60 Fe, 20 Ni, 20 Cr. Magnetostrictive alloys are confined to those of the Fe Ni and Fe Cr series with not over 10% of the third element present. HWG(3)

Carburizing Steels. *Vancoram Review*, Vol. 1, Oct. 1930, pages 145–148.

Brief article lists properties desired in a carburized alloy steel for heavy duty. Physical properties given. (3)

Contribution to the Knowledge of Silicon Structural Steels. (Beiträge zur Kenntnis des Siliziumbaustahles.) H. Buchholtz. *Mitteilungen Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 1, No. 5 (1929) pages 103–145, 49 references.

A comparative study of silicon structural steels and plain carbon steel. The tensile properties of the silicon structural steel particularly the elastic limit, are limited by the rolling conditions and by the rolling temperature. GTM(3)

What Is the Maximum Life of Cast Iron Pipe? B. B. Hodgman. (National Water Main Cleaning Co.) *Water Works Engineering*, Vol. 83, July 30, 1930, pages 1141–1142.

The article considers the old cast iron pipe line build by Louis XIV at Versailles, France, still in operation and estimates the maximum life of cast iron pipe at 500 years and more. GN(3)

Relation between Hardness and Magnetic Properties of Alloys. (Ueber den Zusammenhang zwischen Härte und magnetischen Eigenschaften von Legierungen.) A. Kussmann & B. Scharnow. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Sept. 21, 1929, page 1360.

Three factors influence the hardness of metals and alloys: 1. Constitution, particularly formation of solid solutions, and alloys; 2. Plastic deformation; 3. Other phenomena as for example hardening of steel or refining which are based on a transformation due to a heat treatment. Tests were made with several series of solid solutions; Fe-Al, Fe-Cr, Ni-Cu, Ni-Fe and several heterogeneous mixtures. In some cases it was shown that a determination of hardness can be made by determining the coercive force in magnetic materials. A real regularity in the relation has, however, not been observed. Ha(3)

Molybdenum-steel. (Molybdänstahl.) *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. (1, 1930, page 158.

In 1920, 250,000 tons of molybdenum-steel were produced and used for parts requiring high qualities and reliability due to their application. The composition of 3 different steels with their mechanical behavior is given. Ha(3)

High-grade Steels for Large Structures. (Hochwertige Baustähle für den Grossstahlbau.) E. H. Schulz & H. Buchholtz. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Nov. 2, 1929, pages 1573–1580.

First a review is given of the physical and mechanical properties of structural steels as they were used up to a few years ago for the construction of bridges, large buildings and ships. A table shows that up to 1900 a tensile strength of 37 to 44 kg/mm.^{2} with an elongation of 22% and an alternate bending strength of 18 kg./mm.^{2} was considered satisfactory. Development since that time, however, produced steels of much better properties, and in 1928 the "Union Baustahl" was made with a tensile strength of 56 to 66 kg./mm.^{2} and elongation of 37% and a vibration strength of 31 kg./mm.^{2}. A similar steel of same tensile strength was produced in America as early as 1915, a high-silicon steel. In recent times certain claims as to corrosion and aging must also be met. Diagram and tables illustrate the article. 12 references. Ha(3)

Heat Treatment Determines Properties of Manganese Steel. Harry P. Evans. *Foundry*, Vol. 58, Sept. 1, 1930, pages 102–103.

For casting purposes high Mn steel of austenitic type of 10 to 14% Mn and 1.00 to 1.4% C, and the low Mn steel of pearlitic type of 1.00 to 2.00% Mn and 0.25 to 0.50% C are used. Explains mechanism which confer special properties on that type of steel. Low Mn steel if properly treated will give physical properties comparable to more complex alloy steels. Describes heat treatment. VSP(3)

Physical Properties and Structure of Drawn Steel Wire as a Function of the Preceeding Heat Treatment. (Festigkeitseigenschäften und Gefügeausbildung von gezogenem Stahldraht in Abhängigkeit von der vorangegangenen Wärmebehandlung.) A. Pomp & A. Lindeberg. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 12, *Report* 147 (1930) pages 39–64, 12 references.

Steel wire 0.60% C was patented in a continuous laboratory furnace from different temperatures in various media (air, lead, oil with subsequent tempering). Samples were drawn in 11 drafts with a total reduction of area of 92%. The material was tested as received and after each draft for tensile, bending and elastic properties. The structure was examined. High furnace temperatures, low lead temperatures and moderate reductions in drawing are most favorable. GN(3)

Single Potential of Iron and Steel Electrodes. H. Endo & S. Kanazawa. *Kinzoku no Kenkyu*, Sept. 1930, pages 473–486.

Single crystals of iron, Armco iron and electrolytic iron remelted in a vacuum furnace were used as electrodes; a great care was taken to remove the occluded hydrogen gas in the electrodes and the results −0.689 V, −0.693 V and −0.691 V were obtained respectively. Effect of the nature of surface condition and occluded hydrogen gas on the electrode potential were studied and it was found that the rougher the surface of the electrode, the greater the value of single potential; and a small difference in the grade of polishing of electrode surface does not, however, affect the final potential but only affects the speed of the reaction occurring between electrode and electrolyte. Occluded hydrogen gas causes an increase in potential. Single potentials of annealed steel electrodes of carbon content varying between 0.1–1.4% were studied and concluded that the final values of the single potential for different steels increases at first with increasing content of carbon, reaching a maximum at 0.9% carbon and then decreases with a further increase of carbon content. Potential difference between the electrodes of annealed and globularized eutectoid carbon steels was directly measured. When the structure of the globularized specimen was finer than the pearlitic steel, the former is more electropositive than the latter; and in the case of the coarsely globularized specimen, the potential difference has an opposite sign. These opposite results can be explained by the fineness of the structure. Effect of grain boundary in the electrode on the electrode potential was studied and it was found that the electrode consisting of large grains is more electronegative than that consisting of small grains, and it may be concluded that grain boundary acts more or less to raise the electrode potential. In order to find the effect of small strain on the electrode potential, a large single crystal was gently sawed by hand into 2 pieces. After one of them was strained by 1 Kg. load, their potentials were measured differentially. The strained electrode was more electropositive than the other. When the load was taken off, the potential difference almost disappeared. KT(3)

Change in Electric Resistance Produced in Cold-Worked Metals by Annealing. K. Takahashi. *Science Reports of Tohoku Imperial University, Japan*, Series I (1930) pages 265–282.

The increase of electric resistance due to cold-working is the result of 2 opposite effects. The distance of atoms is increased by cold-working, and the number of free electrons, which may stray off from its own atom to another, diminishes and electric resistance is thus increased. But fibrous structure produced by cold-working has fewer grain boundaries in the direction of cold-working than in other directions, and this produces a decrease of electric resistance. Insoluble impurities which have been segregated in a thin layer in the crystal boundaries and have prevented the flow of electricity, are broken up by cold-working and consequently diminish the electric resistance. Thus the electric resistance first increases and reaches a maximum, as the degree of cold-working increases, and afterward begins to decrease. In the case of silver the maximum is at about 50% reduction. In annealing cold-worked metals, rapid decrease of resistance is observed at such a low temperature as 150° C., where no recrystallization has occurred. This is due to the release of internal stress caused by the cold-working; because this release causes a slight increase of density, and, therefore, results in an increase of free electrons. If annealed at higher temperatures, metals begin to recrystallize first to a pseudo-fibrous structure which on further heating, changes again to polygonal structure. Such a change of structure increases electric resistance. Thus resistance-annealing curves have a minimum point at a certain temperature. KT(3)

CORROSION, EROSION, OXIDATION, PASSIVITY & PROTECTION OF METALS & ALLOYS (4)

Contribution to the Morphology of Rust. (Beitrag zur Morphologie des Rostes.) F. Drexler. (I. G. Farbenindustrie A. G.) *Korrosion & Metallschutz*, Vol. 6, Jan. 1930, pages 3–7.

An X-ray study (powder method, Fe-K radiation) was made of some iron sheets which were allowed to rust in various media. The macrographs and some X-ray photograms are included in the paper which states in the conclusion: Besides Fe-hydroxide-gel only α-and γ-FeOOH could be found as ultimate products of the rust process. As nuclei for the formation of rust, dust-like particles as salts, cinder or soot particles etc. are recognized. The formation of the α and γ-FeOOH seems to depend on the chemical nature of the nucleous substance. The physical structure of the rust is dependent on the modification of the compound FeOOH while the color depends largely on the size of the individual crystal. Electrolytic reactions result in a local decomposition of iron. EF(4)

Corrosion Testing of Duralumin and Its Dependence Upon Chemical Composition. (Untersuchung der Korrosion des Duralumins in Abhängigkeit von seiner chemischen Zusammensetzung.) W. Kroenig. *Korrosion & Metallschutz*, Vol. 6, Feb. 1930, pages 25–34; *Metallurgist*, July 1930, pages 107–109

An exhaustive investigation was performed with 22 Duralumin alloys to study the corrosion resistance in relationship to chemical composition. The test pieces were submitted to submerged and alternate dry and wet tests in sea water solutions. The following types of Duralumin were studied: (1) Al with increasing Cu contents (2), Duralumin with increasing Mg contents and an addition of Mn (3), Duralumin with 4.5% Cu, 0.5% Mg and rising Mn additions (4), Duralumins with increasing Fe contents. Heat treatment, tests on physical properties and microstructural examination are given and the corrosion equipment employed is discussed at length. The paper, which includes 24 illustrations may be summarized as follows: An addition of Cu up to 5.75% exerts a favorable influence upon the physical properties of the binary alloys. Mg in quantities up to 0.96% increases the tensile strength without changing the elongation. Mn favorably influences the physical properties up to 1%; further additions decrease the tensile strength as well as the elongation. An addition of 0.5% Si seems to yield the best result with respect to mechanical properties. Fe impairs the tensile properties. A first grade alloy should not contain more than 0.25% Fe. In regard to microstructure it was established that a rising Mg content results in increasing Cu-containing inclusions. Mn causes a more pronounced elongation of the crystallites in the direction of rolling. Higher contents in Mn and Fe lead to inclusions rising in number and size. Regarding the corrosion resistance it was found that the binary Al-Cu alloys display a different behavior according to the various types of corrosion methods. Intercrystalline corrosion is appreciably reduced by additions of Mg. Small amounts of Mn up to 0.06% increases the resistance to submerged corrosion and in greater amounts accelerates the attack. Si increases the resistance to corrosion up to 0.5%. Fe notably impairs the corrosion resistance of Duralumin. The most advisable composition of Duralumin, according to the author, is 4.5% Cu and 0.6% Mn and the limits of Si are set at 0.5% and of Fe at 0.3% or 0.5% max. No definite statement in regard to the most favorable addition of Mg is given which, however, should be present to counteract intercrystalline corrosion. VVK + EF(4)

Testing and Application of Rust Resisting Coatings in Industry. (Prüfung und Anwendung von Rostschutzmitteln in der Grossindustrie.) O. Mauermann. *Stahl & Eisen*, Vol. 50, July 10, 1930, pages 985–991.

Paper before the Annual Meeting of the Verein deutscher Eisenhüttenleute, May 17, 1930, at Düsseldorf. Includes discussion. The paper gives a survey on the present state of research of rust resisting coatings. The wide scope of coatings and test methods are dealt with. Those coatings are especially referred to, which formed a wide application in industry in consequence of their low price. These are especially bituminous products and products of tar distillation. The results of a $4^1/_2$-year test are reported. Even common tar is a good coating. Most failures are due to excessive mechanical abuse. Nitrocellulose lacquers are considered and finally two new groups of coatings: artificial resin (Harz) and rubber products. "Herolith," an artificial resin product, is absolutely shock proof, has excellent resistance to chemical attack except to caustic alkali and hydrofluoric acid and withstands temperatures up to 220° C. without failure. "Tornesit" a rubber product also resists alkali, stands a dry heat up to 200° C. and is also absolutely shock and blow proof. Both products are manufactured by Herold A. G., Hamburg 33. Tornesit is usually used as a cold coating. GN(4)

Electric Heating Elements. Some Fundamentals Used in Their Design. E. Fleischmann. *Journal American Institute Electrical Engineers*, Vol. 48, Sept. 1929, pages 665–668.

Paper deals with the elementary principles of equations relative to the design of electrical heating elements. The equations are correlated with Stefan's law of radiation and the physical limitations of the problem are discussed. The author is of the opinion that nickel-chromium 80/20 alloy, free from iron, is the outstanding satisfactory resistance material for use at high temperatures. This alloy has the property of forming a complicated surface layer which effectively prevents further oxidation of the body of the resistance element and assures long life: it also gives a consistent and uniform temperature-resistance curve. The paper, which is mathematical in character, is illustrated throughout by curves showing the properties of nickel-chromium 80/20 alloy under the conditions described. (4)

Determining Protection of Underground Pipe through Proper Survey. P. J. Richards. *Water Works Engineering*, Vol. 83, April 9, 1930, pages 491–492, 525.

The author stresses the necessity of discovering the physical characteristics of soil, temperature and stray currents, before the protection of pipe and other underground structures of water distributing systems is decided upon. The nature and extent of coatings is considered. GN(4)

Sprayed Molten Cadmium Coatings in Gasoline Storage Tanks. Leopold Pessel. (Metals Coating Company of America.) *Industrial & Engineering Chemistry*, Vol. 22, Feb. 1930, pages 119–121; *Metal Industry*, N. Y., Vol. 28, April 1930, pages 168–170.

Tests were made to compare the protective values of sprayed molten cadmium and zinc coatings on steel exposed to the action of corrosive gasolines. In 4 series, mixtures of high-sulphur gasoline and distilled water, ordinary gasoline and sea water, ordinary gasoline and distilled water and gasoline containing an organic lead compound and distilled water were investigated. Sprayed molten cadmium coatings were found to be far superior to sprayed molten zinc coatings, although the latter will protect the steel against rust. From the viewpoint of minimizing sludge formation sprayed molten cadmium coatings are ideal. A commercial gasoline containing a small amount of an organic lead compound added as a knock preventive proved to be slightly more corrosive under the test conditions than ordinary gasoline. In this case, too, sprayed molten cadmium remained unattacked. MEH + VSP(4)

Rust Resisting KA2 Steel Used in the Milk Industry. (Nichtrostender Krupp-Stahl (V2A) in der Milchwirkschaft.) Knigge. *Krupp'sche Monatshefte*, Vol. 11, May 1930, pages 87–92.

The author's illustrated paper considers the application of the KA2 steel for various purposes in the milk industry and points to new apparatus and containers in the state of development and testing in this field. The following table gives the attack of lactic acid on KA2 steel at various temperatures.

Lactic Acid	Testing Temperature ° C.	KA2
1.5%	20	Absolutely stable
1.5%	100	Absolutely stable
10% specific gravity 1.02	20	Absolutely stable
10% specific gravity 1.02	100	Absolutely stable
Concentrated specific gravity 1.22	15	Absolutely stable
Concentrated specific gravity 1.22	100	Rather stable

GN(4)

The Influence of Stress Range and Cycle Frequency on Corrosion. D. J. McAdam, Jr. *Mimeographed Advance Copy*, June 1930 Meeting, *American Society for Testing Materials*, 22 pages, 12 diagrams.

Continuation of work on corrosion-fatigue previously described in 13 other papers by the same author. The discussion is so involved and so much reference must be made to the graphs for an understanding of the results that the paper cannot be satisfactorily abstracted. HWG(4)

Practical Problems of Corrosion. *Iron & Coal Trades Review*, Vol. 120, April 25, 1930, page 681; *Journal Society of Chemical Industry*, Vol. 49, April 25, 1930, page 173–180.

Very briefly presents the conclusions drawn by U. R. Evans and C. S. Britton in a paper entitled: "Practical Problems of Corrosion. Part VI. Some Outdoor Tests of Protective Painting, Preliminary Report." This was read before the Society of Chemical Industry. RHP(4)

Corrosion-Prevention Methods as Applied to Aircraft Construction. H. S. Rawdon. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 7 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

Summarizes present practice. Steel parts are Zn or Cd plated, except on hollow parts which cannot certainly be washed clean of plating solution. These are coated with raw linseed oil and plugged tight. A red iron oxide, zinc chromate primer is applied over the plating and covered with spar varnish pigmented with white lead or aluminum powder. Nitrocellulose lacquer is also used. Aluminum alloys with less than 5% Cu are, in Navy practice, given the anodic treatment. Chemical treatment in chromate-containing solutions is sometimes used. Unless these preliminary treatments are given, the surface is cleaned and roughened slightly. The priming coat is usually the same as for steel and the cover coats may also be the same. The Navy uses aluminum-pigmented bitumastic coatings. Alclad (aluminum coated) duralumin is often used without any other coating. Adherence of a paint coating is a prime requisite and the plated coatings on steel and the anodic coating on aluminum alloys improve adherence. Anything that is absorbent or any crevice that can hold moisture by capillarity is very bad in contact with metallic surfaces. Dissimilar metals that would set up electrolytic action must be kept from contact. LM+HWG(4)

Notes on Aircraft Finishes. H. A. Gardner. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 9 pages.

Includes discussion on corrosion prevention along much the same lines as the paper by Rawdon, abstracted above. HWG(4)

A Study of the Error of Averages and Its Application to Corrosion Tests. C. H. Humes, R. F. Passano & A. Hayes. *Preprint*, June 1930 Meeting, *American Society for Testing Materials*, 9 pages.

If all samples of a given material in a corrosion test failed at the same time, only one sample would be required. When failures occur over a time range the number and area of samples that must be tested to give a true measure have to be determined by the methods of statistics. The mathematics of the procedure needed to arrive at the number of samples needed to give reasonable assurance of a given desired accuracy in the mean of the experimental data are discussed. HWG(4)

Atmospheric Exposure and Laboratory Tests on Non-Ferrous Screen Wire Cloth. G. W. Quick. Appendix to report of committee D 14, *Preprint* 24, June 1930 Meeting, *American Society for Testing Materials*, 17 pages.

After about 4 years exposure, no appreciable reduction in strength is noted in specimens of 7 kinds of non-ferrous screen wire cloth exposed at the Bureau of Standards, Washington. One failure, that of Monel metal, occurred in the specimens exposed at Pittsburgh, and one, that of 80 Cu, 20 Zn brass at Portsmouth, Va. The latter failure was by dezincification. Average sulphur dioxide content of the atmosphere in Washington, D. C., over a one year period, 1927–28, ranged from 0.07 parts per million in June to 0.27 in February. In Pittsburgh, from 0.02 in July to 0.67 in October. At Panama Canal, average figures ran from 0.06-1.00; at Portsmouth, Va., from 0.48–1.17. Although the sulphur dioxide determinations were made by the same method, aspiration through iodine-starch, and in the same type of apparatus, it seems doubtful to the abstractor if the figures really represent the variation in SO_2 content of the atmosphere at all these locations. HWG(4)

On the Theoretical Consideration of Oxidation of Metals. T. Nishina. *Kinzoku no Kenkyu*, July 1930, pages 379–384.

On the standpoint of the kinetic theory of gases and under the assumption that oxidation means a diffusion of oxygen in metals so as to form a uniform phase, B. Pilling and E. Bedworth's experimental equations $W^2 = Kt$ and $K = AO^n$, where W is the quantity of oxygen absorbed in the metal, t is the time, K is diffusion constant, O is absolute temperature, A and n are constant, were proved to be correct theoretically. KT(4)

Corrosion of Magnesium in Various Salt-Solutions. H. Endo and K. Miyasaki. *Kinzoku no Kenkyu*, June 1930, pages 283–301; July 1930, pages 329–342.

Corrosion of magnesium by various salt-solutions such as sodium chloride, sodium nitrate, sodium sulphate, sodium carbonate, potassium chromate and potassium bichromate, were measured by the weight loss and also by the measurement of hydrogen gas liberated. A maximum corrosion of sodium chloride solution occurred at 1.25 g. mol. of it. This was explained by the fact that the occurrence of the maximum solubility of magnesium hydroxide in sodium chloride solution is at a point 1.25 g. mol. of sodium chloride. The corrosion of the solution of sodium nitrate or sodium carbonate decreases first and then increases with the content of the salt. The equivalent corrosion of these salts with that of water is at 0.62 and 1.25 g. mol. respectively. The beginning of corrosion by the aqueous solution of potassium bichromate and potassium chromate was found at the concentration of $^1/_{500}$ to $^1/_{700}$ and $^1/_{800}$ to $^1/_{1000}$ g. mol. respectively. When potassium bichromate or potassium chromate was added to a solution of constant concentration of sodium chloride the maximum corrosion was found to be at $^5/_{30}$ g. mol. in the former case, but no such point in the latter, and the corrosion decreased with the concentration. When the concentration of potassium bichromate or potassium chromate was kept constant and sodium chloride was added, the maximum corrosion was at the concentration of 100 g. per liter in the former case and 150 g. per liter in the latter. The quantity of hydrogen gas liberated indicates the degree of corrosion; in sodium chloride solution, a maximum hydrogen was liberated at the concentration of $^5/_8$ g. mol. If in a solution containing $^5/_{30}$ g. mol. of potassium bichromate 5 g. of sodium chloride was added, greater quantity of hydrogen was liberated than in the case in which 5 g. of sodium carbonate or sodium sulphate was added. KT(4)

Corrosion of Light and Extra Light Alloys. (La Corrosion des métaux et alliages legers et ultra legers.) R. Cazaud. *Revue de Metallurgie*, Vol. 28, Part I, June 1930, pages 285–300; Part II, July 1930, pages 337–351.

A survey by R. Cazaud of the work by different investigators on the subject. The abstracts are given under the original title and the name of the worker below.

Methods of Control and a Study of the Mechanism of Corrosion. (Methodes de controle et étude du mechanisme de la corrosion.) E. Herzog & G. Chaudron.

A careful study of corrosion of Al, soft steel, Cu and Al alloys in 1% NaCl with 1% H_2O_2 kept in a thermostat at 35° showed that the loss of weight cannot be considered as an index of the residual properties of the specimen. When corrosion is uniform a specimen tested after corrosion has the same physical properties as before, when actual reduction of the cross section is discounted. With the localized corrosion the tensile strength remains about the same but the elongation rapidly drops even for very small losses in weight. This effect is due to the perforation of the surface and can be reproduced by drilling small holes in a fresh sample. Removal of the superficial perforated layer restores to the rest of the specimen the original properties. With intercrystalline corrosion this cannot occur. Tables of physical properties after corrosion are given.

Diminution of Mechanical Properties Under the Influence of Corrosion. (Diminution des proprietes mechaniques sous l'effet de la corrosion.) Cournot & Molnar.

Physical properties of Al alloys immersed in sea water or in its spray for 165--200, 310, 600 and 1200 hours were studied with the aim of finding a possible relation between the degree of corrosion and physical properties. A table of the values obtained shows that the spray acts somewhat faster, elongation is in closer relation to the corrosion than any other property and it is almost impossible to rely on elastic limit.

Demonstration of the Areas of Action of Galvanic Couples. (Mise en vue de la zone d'action des couples galvaniques.) Cournot & Molnar.

Disks of Al and duralumin had a rivet placed in their center and immersed in salt water. Metals used for rivets: Cd, Zn, Fe, steel, Al, duralumin, brass and Cu. Al appears to be less attacked than duralumin. It corrodes near the rivet and more or less uniformly. On duralumin lesser number of points of attack were observed, but each of them had a more copious deposit of Al(OH)$_3$. Cd and Zn offer considerable protection; Fe promotes corrosion very pronouncedly especially with duralumin. Cu is very detrimental. Brass less. Several rivets of the same type in a disk accentuate the corrosion. Al corrodes around rivets, duralumin all over. A Cd or Zn rivet was placed in the center of disks and was surrounded with several Cu rivets. After 48 days in natural salt water Cd protected the metals well, especially duralumin. Zn helped only a little by forming a layer of Al and Zn oxides. Protecting effect of Cd and Zn in the presence of Cu was studied by surrounding a Cd or Zn rivet in a disk with several copper rivets. The test run 48 days showed that Cd neutralizes the effect of Cu and gives good protection, Zn helps less, by forming a coat of oxides. Cu alone strongly increases corrosion concentrating it around rivets. Substitution of Cd rivets by Cd plated duralumin rivets reproduced the effect of the former and seems to be very promising for airplane construction. The effect of the closeness of the contact between disks and rivets was studied. It is very important for prevention of the corrosion in sea water. Similar experiments conducted on disks of Mg and its alloys using fresh water as corroding medium and 55 days immersion showed that galvanic action created by these couples is not sufficient to overcome the corrodibility of Mg.

The Study of Solubility by Means of EMF. (Methode des forces electromotrices de dissolution.) Aubert & Prot.

With proper experimental refinements, e.m.f. generated during solution was studied, and applied to the investigation of the mechanism of solution. Pure metals, very homogeneous alloys and solid solutions resist corrosion better than heterogeneous alloys. Heat treated duralumin corrodes less than annealed. To protect a metal one has to form a homogeneous layer on its surface. Irregularities in heat treatment may result in irregularities in e.m.f. and accelerated corrosion. For heterogeneous alloys the corrosion is less when the couples formed by its components are weaker and polarization stronger. For application to corrosion problems a continuous record of e.m.f. is necessary.

Final Studies of the Elevation of Temperatures in Aluminum Alloys on Activation. (Essais resultatifs a la mesure des elevations de temperatures d'alliages d'aluminium actives.) Quillard.

Inserting a sensitive thermometer into a bar of Al alloy and inserting the system in a solution of HgCl$_2$ one can observe that the rate of heating is strongly affected by very small changes in composition and heat treatment. The method can be applied to the study of heat treatments of Al alloys.

Influence of Arsenic on the Corrodibility of Light Alloys by Sea Water. (Influence de l'arsenic sur l'attaquabilite a l'eau de mer des alliages legers.) R. Cazaud.

Several heats were prepared by introduction of arsenic as eutectic alloy with copper or manganese to aluminum alloy adjusted to duralumin analysis. Alloys with 0.20, 0.30 and 0.80% As were studied. In rolling the metal tends to crack requiring annealing after every pass. It cannot be rolled above 400° on account of volatilization of As. Intermittent immersion into sea water for 40 hours did not show any appreciable difference between corrosion of usual and arseniferous duralumin.

Methods for Surface Protection. A Study of the Use of Grease for Protection of Aluminum Against Chemical Changes. (Moyens de protection superficiels. Essai sur l'emploide corps gras en vue de la protection de l'aluminium contres les alterations chimiques.) A. Trillat.

Good protection offered to Al by greasing lead to further investigations. Many hydrogenated oils offer a better protection to Al than the usual greases. Former failures were attributable to the particles of coloring matter forming galvanic cells with the metal. Simple smearing renders Al practically immune to ordinary corrosion. The grease layer must be thin, made flexible by addition of lanoline and free from solvent. Al sheets 1 m.^{2} greased as recommended and placed in river water with the current of 5–10 m./sec. after 6 months showed perfectly sound coating while the parts not greased were erroded by the sand carried in water. Adherence of coating is strong. A stream of water with up to 12 kgs./mm.^{2} pressure and impinging on specimens at any angle cannot destroy it in 5 minutes.

The Method of Application of So-Called Phenol Process to Light Alloys. Specifications for Raw Materials. (Conditions d'application du procede de protection des alliages legers d'aluminium dit "Procede auphenol" Conditions de reception des produits constitutifs.) Aubert & A. Pignot.

A successful protection to light alloys is offered by a coating made of rosin and phenol. The manner of application for satisfactory results and the specifications for raw materials are briefly given.

The Resistance of Duraluminum Plates Protected by Different Methods to Natural Sea Water. The Influence of Sandblasting. (Essais de Resistance a L'eau de mer Naturelle de Plaques de Duralumin Avant Recu Diverses Couches Protectrices. Influence de Sablage.) Quillard.

A study of the influence of sand blasting on the corrodibility of Al in sea water. Specimens were coated with a double layer of Na silicate which was baked on either on a clean face or on the face activated with HgCl$_2$. Check specimens were coated with paraffine. Visual examination showed that sand blasting increases the corrodibility somewhat.

Results of Practical Testing. Resistance of Special Light Alloys to Natural Sea Water. (Resultats d'essais pratiques. Essai de resistance a l'eau de mer naturelle d'alliages legers speciaux.) Legendre.

Light alloys after immersion in the sea showed much better corrosion resisting properties for alloys free from Cu than for Cu bearing.

Results of Practical Testing of Plates and Caissons Made of Light Alloys. (Resultats d'essai pratique de plaques et de caissons en alliages legers.) Legendre.

Strips of duralumin were joined to strips of other metals and immersed in the sea for $2^1/_2$ months. To half of these couples were attached Zn strips to create galvanic couple. The presence of Zn under these conditions resulted in some improvement of the surface and of physical properties after immersion.

Some Conclusions to be Drawn from the Results Obtained at Saint Raphael. Practical Testing of the Caissons. (Ensignements a tirer de quelques resultats obtenus a Saint Raphael. Essais practiques sur caissons.) Lecoeuvre.

Some results obtained in comparing the efficiency of different methods of protecting light alloys immersed in the sea. Different types of organic coatings, coatings made by Schoop process and electrolytic and anodic protection were tried. Many of the tried methods can be considered as effective. JDG(4)

On the Corrosion of Aluminum. (Ueber die Korrosion des Aluminiums.) H. Rohrig. *Korrosion & Metallschutz*, Vol. 5, Nov. 1929, pages 244–245.

The author reviews in his illustrated paper the principal corrosion attacks of aluminum in service due to surface scratches by iron objects, soft soldered spots, contact with Fe, etc. EF(4)

Corrosion and Metal Protection in Boiler Operations (Korrosion und Metallschutz im Dampfkesselbetrieb.) R. Stumper. *Korrosion & Metallschutz*, Vol. 5, Oct. 1929, pages 230–235; translation in *Metals & Alloys* Vol. 1, Dec. 1930, pages 895–896.

The author lists the various sources leading to boiler corrosion. Emphasis is placed on the corrosion due to formation of boiler scale. Overheating and direct chemical action due to thermal decomposition of the scale with liberation of corrosive substance at the metal surface is discussed in detail. Stumper, who discusses several typical failures in service, assumes that the boiler water diffuses through the pores of the scale forming a liquid layer between the scale and the boiler plate. EF(4)

Rules for the Practical Testing of the Corrosion Resistance of Steels. (Richtlinien für die praktische Prüfung von Stählen auf ihren Korrosionwiderstand.) E. H. Schulz. *Stahl und Eisen*, Vol. 50, Sept. 4, 1930, pages 1266–1269, 5 references.

Report 164 of the Material Committee of the Verein deutscher Eisenhüttenleute. Rules are proposed in order to standardize corrosion tests. The behavior of steels toward corrosion can be determined exactly only by tests requiring a long time. Rules are given for taking the samples to be tested, preparation and marking of samples and the observation of the corrosion process. Rules are also outlined for short time corrosion tests, generally applied in laboratory tests, which, in many cases, pass reliable judgment. GN(4)

Unusual Corrosion of Aluminum by Alkali. Oliver W. Storey. *Preprint* 58–4, *American Electrochemical Society*, Sept. 25–27, 1930, pages 43–48.

A peculiar case of pitting aluminum electric oven walls was investigated. The corrosion of the aluminum was found to be caused by the caustic soda of the sodium silicate adhesive used for the built-up asbestos insulation, in the presence of excessive moisture. The sheet asbestos acts as a dialyzing membrane for the sodium silicate and allows silicate-free caustic soda to reach the aluminum sheet. (4)

On Corrosion Phenomena. The Explanation of the "Difference Effect." (Ueber Korrosionerscheinungen. Die Erklärung des Differenzeffektes.) E. Thiel & W. Ernst (University of Marburg). *Korrosion & Metallschutz*, Vol. 6, May 1930, pages 98–103.

The present paper largely pertains to the study of the "difference effect," which is noticed when the dissolving of an unnoble metal is retarded by the presence of another suitable metal so that a local element is formed. The decrease of the dissolution is under certain conditions proportional to the discharge current of the local element which phenomenon is designated as "difference effect." The authors established (1) the difference effect to be a pure resistance phenomenon, (2) the discharge of the local element follows Ohm's Law thus proving the fundamental importance of conductivity during the process of discharge, (3) the theory of Palmaer holds true for the metal dissolving as far as the influence of local elements is concerned. EF(4)

Painting of Steel Buildings. (Anstrich von Stahlhäusern.) K. Würth. *Korrosion & Metallschutz*, Vol. 5, Dec. 1929, pages 274–279.

Paper presented before the Reichsausschuss für Metallschutz, Vienna, 1929. EF(4)

Heat Treatment of Chromium Deposits to Increase Their Resistance to Corrosion. R. J. Wirshing. *Preprint* 58–19, *American Electrochemical Society*, Sept. 25–27, 1930, pages 251–253.

Copper panels chromium plated at low current densities and high bath temperatures were more resistant to calcium chloride corrosion than panels plated at higher current densities and/or lower temperatures. Greater corrosion resistance is attributed to lower hydrogen content of the plate. Upon removing most of the hydrogen through heat, a seven-fold improvement in corrosion resistance was noted. (4)

Comparative Study of the Protective Action of Cadmium-, Zinc- and Other Coatings. (Vergleichstudium der Schutzwirkung von Cadmium-Zink- und anderen galvanischen Ueberzügen.) N. A. Isgarischev. *Korrosion & Metallschutz*, Vol. 6, July 1930, pages 156–161.

Using several improvements in plating, corrosion in soil, sea-water and oxygen was investigated. Decrease in corrosive action, especially of cadmium plating in consequence of passivity, followed increase of pH of soil; at pH = 4.08, the potential difference increases with time; at pH = 4.97 and more, potential difference decreases with time. In sea water, through which air is blown, corrosion of cadmium and zinc occurs much more slowly than without air in consequence of formation of protective oxide film; the bare iron plates were destroyed 3 times as fast with air than when no air was blown through. With a good coating, oxidation occurs over entire surface of zinc- and cadmium-coated plates; in the former the corrosion products are looser and form more rapidly; the cadmium oxides adhere very well to the surface, forming a coating with specially good protective action. Cadmium is far superior to zinc for corrosion protection. W(4)

Heavy Corrosion Attack on the Shell of an Ocean Liner. (Die Ursachen starker Anfressungen an den Aussenhautplatten eines Ueberseedampfers.) M. Rudolph. *Korrosion & Metallschutz*, Vol. 5, Nov. 1929, pages 246–247.

Pipes and blow-holes discovered in the defective steel are considered to be largely responsible for the heavy corrosion which is theoretically explained with the help of Evans' theory. EF(4)

A Proposed Method for Accurately Evaluating Results of Corrosion Tests of Ferrous Metals. Karl Pitschner. *Preprint* 58–13, *American Electrochemical Society*, Sept. 25–27, 1930, pages 173–185.

Methods of procedure, analysis and calculation are described which provide a definite means of evaluating the data of corrosion tests on the ferrous metals, of determining the actual protective value of coatings on these materials and of comparing their tendencies to pit under corrosive conditions. The procedure depends on a method for determining the element iron in the metallic portion of corroded samples by means of a separation of corrosion products from metallics, with crystalline iodine. (4)

The Resistance of Electro-Deposits to Corrosion, with Special Reference to Cadmium and Zinc. W. S. Patterson. *Sheet Metal Industries*, Vol. 4, Aug. 1930, pages 294–298; *Metal Industry* (London), Vol. 36, May 16, 1930, pages 527–529; *Brass World*, Vol. 26, Aug. 1930, pages 210–212.

The article to be continued. Paper read before the Electroplaters' and Depositors' Technical Society at the Northampton Polytechnic Institute, Clerkenwell, London, E.C.1. "Bibliography" of 13 references to date. As factors governing corrosion, acid, neutral salt solutions, atmosphere, purity of deposit, porosity of deposit and influence of polishing are given. Tables and graphs of results on indoor corrosion, in unsaturated and saturated atmospheres, of cadmium and zinc are presented. AWM + WHB(4)

Process for Protecting Zinc Coatings. *Brass World*, Vol. 26, Aug. 1930, page 207.

A new process for increased protection of galvanized surfaces against corrosion has been developed by the Liquid Metal Products, Inc., Chicago, Ill. The process consists of dipping or painting with "Stibloy" a metallic liquid produced and distributed under Arent antimony patents. After one treatment with this liquid, the surface may be readily painted, enameled or lacquered. Application of "Stibloy" is followed by 3–5 hrs., which water is applied over the whole surface to complete the treatment. WHB(4)

Alloys that Resist Heat. T. Holland Nelson. *Iron Age*, Vol. 125, Feb. 6, 1930, pages 431–434; Feb. 20, 1930, pages 578–580.

These are the fourth and fifth articles in a series on stainless steels and irons, corrosion and heat resisting alloys. There are four classes of heat resisting alloys: (1) Alloy containing approximately 60% nickel or upward with 20% of chromium or higher with iron from 10 to 20% down to traces only. (2) An alloy with from 25 to 40% nickel and from 10 to 20% chromium, the remainder iron. (3) Various modifications of from 15 to 25% chromium with from 8 to 15% nickel. (4) Alloys containing 7 to 14% chromium, with silicon from 0.5 to 5.0%. Author claims that heat resistance and corrosion are the same problem. Selection of suitable material is not a simple problem. VSP(4)

Criticisms of the Methods for the Removal of Rust. (Kritik der Entrostungsverfahren.) P. Nettmann. *Korrosion & Metallschutz*, Vol. 6, May 1930, pages 106–111.

This paper, presented at the Session of the Reichsausschuss für Metallschutz, March 1930, considers the various rust removing methods with emphasis of their economy. EF(4)

Some Metallurgical Problems Connected With the Possible Use of Very High Steam Temperatures. J. H. G. Monypenny. *Metallurgia*, Part 1, Vol. 2, May 1930, pages 22–25; Part 2, June 1930, pages 46–48.

During the past few years steam temperatures as high as 750° F. have been used, and temperatures as high as 1000° F. are now being suggested. At 750° F. carbon steels are usually satisfactory, but their strength at higher temperature is inadequate, and they do not have sufficient resistance to corrosion and erosion. Austenitic chromium-nickel steels have been found to be sufficiently resistant to corrosion up to 1200/1250° F. Steam and mild steel react at temperatures above 900° F. to produce hydrogen and iron oxide. Creep tests and the variable results obtained by different investigators are discussed. As a material for superheater tubes a high chromium or an austenitic nickel-chromium steel is recommended. It is believed, however, that additional tests are necessary to prove the stability of the latter steel because of the danger of intercrystalline corrosion at elevated temperatures. There appears to be no advantage in increasing the chromium above 13 or 14%. For bolts subjected to high temperatures a low alloy nickel-chromium steel is probably satisfactory. These steels are susceptible to "temper brittleness," and the addition of molybdenum may be necessary to free the steel of this defect. Curves are given which show that the impact values of a steel containing molybdenum are higher than other alloy steels after having been heated to elevated temperatures. JLG(4)

Corrosion Phenomena on Aluminum Alloys. (Korrosionserscheinungen an Aluminiumlegierungen.) E. Maass & W. Wiederholt. *Korrosion & Metallschutz*, Vol. 5, Dec. 1929, pages 265–270.

Various Al alloys, the analyses of which are listed in the introduction, were tested in 5 n, 0.1 n and 0.01 n NaOH after annealing all samples at 300° and 500° C. respectively. The solution of Al in caustic solutions takes place without noticeable induction period as noticed in acids. Hydrogen was evolved until protective layers were formed. The color and tenacity of the $Al(OH)_3$ film was largely dependent on the chemical composition of the Al alloys tested. Regarding the concentration of the corroding medium it was found that in more diluted solutions protective layers were formed whereas there was no evidence in case of higher concentrations. Consequently a rapid and uniform attack took place in strong solutions. With respect to the heat treatment, the authors state that annealing at 500° reduce the corrodibility of the alloys while annealing at 300°, in general, tended to increase the corrosion attack. In regard to the composition of the various Al alloys investigated, the authors established that additions of elements insoluble in Al gradually decrease the corrosion resistance against NaOH due to the formation of local elements. If insoluble corrosion products were formed, a dense, adhesive film was often formed. The behavior of these films, however, varies due to uncontrollable influences thus obstructing clear conclusions and interpretations. The order of merit among the different Al alloys is given as follows: Cu–Mn–Mg alloys tend to form rather resistant films showing a longer corrosion rate after three weeks than at the start. The hydroxide layer was not very dense if other metals were present, mainly Zn, Ni, Si. Cu–Mn–Mg alloys of Al showed the least loss in weight, whereas other Cu alloys were relatively strongly attacked. The largest loss in weight was found in pure Al. There was, however, little difference in corrosion resistance of the various alloys if the protective film was removed. EF(4)

Supplementary Study of the Evans Theory. (Beitrag zur Kenntnis der Evanschen Theorie.) E. Maass & E. Liebreich. *Korrosion & Metallschutz*, Vol. 6, March 1930, pages 49–53; May 1930, pages 103–106. **The Distribution of the Corrosion Occurring Under a Drop. (Ueber Verteilung der unter Tropfen entstehenden Korrosion.)** U. E. Evans (University of Cambridge). April 1930, pages 74–78.

These 3 publications represent a controversy on the value of the drop corrosion test and its interpretation by Evans. In the first paper Maass & Liebreich report on drop tests on electrolytic iron with 1 n KCl, 0.1 n HCl and 0.1 n H_2SO_4. The drop was constantly in contact with the plate and suspended from the tip of a pipette filled with the corroding medium. The latter was saturated with oxygen in order to prevent absorption from the air and to keep the middle of the drop at a higher concentration than the edge. The experiments yielded results which were in accordance with the determinations of Evans only in case of electrolytes which were not saturated with oxygen. A central attack with a well-defined rim around the circumference of the drop occurred. No agreement with the Evans theory could be obtained if the corroding medium contained oxygen, i. e. in case of the passifying electrolytes. The attack was more pronounced at the rim or entirely lacking. The authors assume that the electrolyte concentration increases in the center of the drop because of convection currents induced by evaporation bringing about the attack either by greater concentration of the corrosive constituent or by decreasing the solubility of oxygen. The same reason holds for passifying solutions which, according to the authors, afford more protection to the metal area in the center of the drop. Evans in his article doubts the actual oxygen distribution assumed by Maass & Liebreich and conducted experiments with revised experimental devices so as to ascertain a certain oxygen concentration on the center of the drop. The need for using neutral solutions instead of acids is emphasized if the theory is to be valid for interpretation of corrosion phenomena in the region of pH in which natural water corrosion occurs. In the last paper by Maass & Liebreich give another set of experiments to explain the central corrosion attack of the drop by means of current phenomena instead of by the theory of differential aeration. EF(4)

Testing Procedure for Determining the Corrosion of Aluminum and Aluminum Alloys. (Prüfverfahren zur Feststellung von Aluminium und Aluminiumlegierungen.) E. Maass. *Korrosion & Metallschutz* Vol. 6, July 1930, pages 146–150.

Systematic procedure worked out by the "Aluminum Committee" of the Reichausschuss für Metallschutz (E. Maass, Chairman), with the aid of the Deutsche Gesellschaft für Metallkunde in planning the project. ACW(4)

Corrosion of Metals. *Electrical West*, Vol. 64, May 15, 1930, pages 412–413.

Report of Subcommittee on corrosion of metals, Overhead Systems Committee, Engineering Section, Pacific Coast Electrical Association. Deals with corrosion of transformer cases, hangers, pole top switches and line hardware. Recommends use of a good grade of galvanizing to obviate corrosion troubles. MS(4)

RARE METALS AND ALLOYS

TANTALUM · · · TUNGSTEN · · · MOLYBDENUM · · · CAESIUM · · · RUBIDIUM

ACID-PROOF

not merely
"corrosion resisting"

TANTALUM
an element—not an alloy

THE term "corrosion resisting" merely means that sooner or later the material fails, and must be replaced. Any metal is "corrosion resisting" to a certain degree.

Tantalum, *resistant* to all corrosives, is *proof* against all but two.* Its only rivals are gold and platinum. And for most purposes Tantalum is better—at lower cost.

Another thing—Tantalum is not an alloy, not variable, not subject to change or discontinuance of manufacture. It is a basic element, as staple as iron, copper or lead.

And like these metals, it is easily formed, fabricated and welded. It can be machined with ordinary tools. It can be hardened or annealed, from the toughness of steel to a lead like softness. It is easily polished and can be finished in a variety of controllable colors.

Manufacturers are continually finding new uses for Tantalum. Many others are due to make large profits from its use. It's worth investigation.

The Fansteel laboratory will furnish samples and full cooperation.

*Only hydrofluoric acid or hot concentrated caustic will attack Tantalum.

TANTALUM · · · TUNGSTEN · · · MOLYBDENUM · · · CAESIUM · · · RUBIDIUM

FANSTEEL PRODUCTS
COMPANY, Inc.
NORTH CHICAGO, ILLINOIS

Corrosion Experiments with Monel Metal and Corrosion Resistant Bronze. (Korrosionsversuche mit Monel-metal und säurefester Bronze.) M. G. Binek. *Korrosion & Metallschutz*, Vol. 5, Nov. 1929, pages 247–248.

The material employed in the present investigation had the following composition: Bronze of 81.6% Cu, 10.0% Pb, 7.9% Sn and small amounts of Fe, Zn, Ni and P; Monel metal or 62.2% Ni, 34.7% Cu, 3.0% Al and small quantities of Fe and Pb. The samples were exposed to the influence of pure diluted H_2SO_4 (19.5%) chamber acid containing nitric acid (same concentration), contact acid free from HNO_3 and 10% HCl. The temperature was maintained at about 60°. In all the tests Monel metal was superior to bronze. The smallest corrosion attack was observed in chemically pure acid and increase in the following order: contact acid, H_2SO_4 containing HNO_3. The heaviest corrosion attack was produced by HCl. EF(4)

The Application of Sea Water for Metal Coloring. (Ueber die Verwendung von Meerwasser zur Metallfärbung.) E. Beutel & A. Kutzelnigg. (Technologisches Institut of the Hochschule für Welthandel, Vienna.) *Korrosion & Metallschutz*, Vol. 6, March 1930, pages 53–55.

The authors carried out experiments with the object of replacing the expensive pickling solutions by natural corroding reagents and exposed iron, steel, brass, copper, zinc, aluminum and silver to the corrosion attack of salt water from the North Sea. Various solutions were furthermore tested to accelerate the oxidation of Cu in sea water, mainly by hydrogen peroxide, sodium perborate, potassium permanganate and ferrocyanide. EF(4)

Attack of Aluminum by Ammoniacal Solutions. (Sur l'attaque de l'aluminium par les solutions ammoniacales.) J. Calvet. *Comptes Rendus*, Vol. 189, Sept. 30, 1929, pages 485–486.

Three samples of the cast metal, purity 99.96, 99.71 and 99.18% respectively were subjected to the action of aqueous ammonia for 2 and 22 days, and the degree of attack was measured by the loss in weight after the removal of the surface coating. In 20% ammonia (by volume) the loss in weight in mg./cm.^{2} of the samples in the order mentioned above was: at the end of 2 days, 32.6, 31.5 and 28; at the end of 22 days, 35, 34 and 31. For 10% ammonia the results were about the same as for 20%, while for concentrated ammonia the results were less than half as great. (4)

Influence of Different Salts on the Solution of Pure Aluminum in Hydrochloric Acid. (Influence dedivers sels sur la dissolution de l'aluminium pur dans l'acide chlorhydrique.) J. Calvet. *Comptes Rendus*, Vol. 189, July 22, 1929, pages 183–186.

The author continues a description of tests on the solution of extra-pure aluminum in dilute hydrochloric acid solutions, and examines the effect produced on its long period of passivity by the addition of small quantities of salts of other metals. A table gives concentrations of different salts/liter of solution, duration of tests and loss in weight of aluminum specimens in mg./cm.^{2} (4)

Corrosion Fatigue. An Explanation of Boiler-Plate Failure. H. C. Dinger. *Power*, Vol. 71, Jan. 28, 1930, pages 133–134.

Defective workmanship is responsible for most boiler failures. Corrosion s usually only a minor contributing factor. (4)

Heat-Resisting Cast Iron. J. W. Donaldson. *Metallurgia*, Vol. 2, May 1930, pages 29–30.

The theories advanced to explain growth of cast iron are reviewed. The decomposition of the cementite is responsible for most of the growth. To produce heat resistance iron a low total carbon content, and silicon below 1.1% are desirable. The combined carbon should be between 0.8 and 0.9%, and the graphite should be fine. The phosphorus content should not exceed 0.5% and the sulphur 0.08%. The manganese content is best kept between 0.5 and 1.0%. Chromium stabilizes the carbide, but may render machining difficult. Nickel alone is undesirable, but combined with chromium gives good results. JLG(4)

Passification of Metallic Surfaces by Electrons. (Passivieren von Metalloberflächen durch auftreffende Elektronen.) F. Goldmann & E. Rupp. *Zeitschrift für physikalische Chemie*, Vol. 6, June 1930, pages 180–186.

Metallic surfaces which are not degasified can be passified by electrons. Carr showed how to trace an electron ray on copper by means of iodine vapor. The passification can be produced either by slow electrons, say, down to 100 Volts, or by rapid electrons of a Leonard-Coolidge Tube of 150 KV. Besides this positive ions act passifying as well as ultra-violet rays. No passification takes place on metals which are free from gases not even in case that one direct hydrogen against the surface of the metal. However, passification shows up after the metal being exposed to oxygen. It is justifiable to conclude, according to the authors, that the process of passification must be ascribed to the formation of an oxide film due to the influence of the electrons. EF(4)

Corrosion of Aluminum Alloys in Superheated Steam. (La corrosion des alliages d'aluminium dans la vapeur d'eau surchaufé.) Léon Guillet & Ballay. *Comptes Rendus*, Vol. 189, Oct. 14, 1929, pages 551–553.

The article states that the deterioration of aluminum alloys in superheated steam at 300–350° is due to the formation of alumina, and that it occurs at the junction of grains. It concludes that the deterioration is influenced by the presence of other metals and is greatest for the purest samples of aluminum in both still and circulating steam and least for alpax (13% Si). Corrosion also appears to depend on thermal and mechanical history of the alloy. (4)

Corrosion of Copper. I. (Korrosion von Kupfer. I.) L. W. Haase. *Metallwirtschaft*, Vol. 9, June 13, 1930, pages 503–506.

A descriptive review of the corrosion of copper by chemicals. Gases do not attack Cu except in the presence of moisture. In liquids the presence of O is required as Cu is usually not soluble itself, but oxide forms and it is dissolved. It is not attacked much by inorganic neutral salts. Salts, whose cations form soluble salts with Cu, attack it more than those which form insoluble salts. Cu is attacked by sulphides, as the resulting CuS oxidizes to $CuSO_4$ which is soluble. Chlorides are most corrosive, especially NH_4Cl. Sea water attacks Cu due to the presence of $MgCl_2$ which hydrolizes. Cu is attacked by acids only in the presence of air, the oxide being readily dissolved. KOH and NaOH have a slight effect, $Ca(OH)_2$ none. NH_4OH corrodes in presence of air. Fatty oils attack Cu more than saturated oils. Traces of Cu are sometimes found in alcohol and beverages due to their containing some acetic acid. Acetic acid dissolves Cu salts. Chemical attack of Cu is sometimes aided by electro-chemical action. CEM(4)

The Anodic Protection Treatment of Aluminum and Its Alloys. (Die anodische Schutzbehandlung von Aluminium und seiner Legierungen.) M. Haas & E. Weitz (Technische Hochschule Aachen). *Korrosion & Metallschutz*, Vol. 6, June 1930, pages 121–127.

Investigations were carried out with purest American Al (99.96%), Duralumin 681A, 681B, 681B1/8, Lautal, Aludur, Konstructal 8 and Silumin. The object was to re-examine the process of anodic oxidation in an electrolyte of pure chromic acid, according to Bengough. The following factors are considered as being prerequisite for securing a fair anodic protection film: thoroughly clean surface, constancy of bath temperature and a pure electrolyte. It was found that the testing method according to Bengough is well applicable to the investigation of the light metals listed above. Commercial utilization is recommended in case of Duralumin, Lautal and pure Al. The anodic oxidation in chromic acid reveals surface defects by a yellow colorization after the oxidized test piece has been cleaned with water. EF(4)

Corrosion Resistance of the Platinum Metals. (Die Korrosionsbeständigkeit der Platinmetalle.) *Deutsche Goldschmiede-Zeitung*, Vol. 33, May 24, 1930, page 5.

Gives a table showing the solutions that attack or dissolve metals of the platinum group. JLG(4)

Changes in the Mechanical Properties of Duralumin Sheet after Corrosion by Sea Water. (Sur l'altération des propriétés mécaniques des tôles de duralumin après corrosion par l'eau de mer.) E. Herzog & G. Chaudron. *Comptes Rendus*, Vol. 189, Dec. 9, 1929, pages 1087–1089.

The elongation of duralumin sheet of 2 mm. thickness decreased very markedly after exposure to ordinary sea water, sea water to which H_2O_2 had been added and NaCl solution under 25 atmospheres pressure. The tensile strength did not suffer much as long as the loss of weight did not exceed 2%. In thinner sheets both elongation and tensile strength decreased very much. Penetration tests made with the same materials showed that the proportion $\Delta F\%/\Delta m\%$, in which $\Delta F\%$ represents the decrease of the breaking load and $\Delta m\%$ the loss of weight, was always larger than 10 in this type of corrosion. With a 5% NaOH solution used as a corroding medium this proportion was approximate. Results similar to corrosion may be obtained by damaging the surface mechanically. By polishing the surfaces that had been subjected to chemical or mechanical attack the original tensile strength and elongation could be restored to the material. (4)

Outdoor Atmospheric Corrosion of Zinc and Cadmium Electro-deposited Coatings on Iron and Steel. C. L. Hippensteel & C. W. Borgmann. *Preprint* 58–1, *American Electrochemical Society*, Sept. 25–27, 1930, pages 1–11.

Experimental data are presented on the rates of corrosion of electro-plated zinc, zinc alloy and cadmium protective coatings on steel in a severely industrial atmosphere, and in a similar atmosphere, but accelerated by additional rainfall simulated by a water spray. These data show that zinc and zinc alloy coatings corrode at a slower rate than cadmium coatings. However, under the accelerated exposure the difference is not so pronounced. (4)

The Behavior of Heat Resisting Alloys toward Sulphur and a New Sulphur-Resisting Alloy. (Das Verhalten hitzebeständiger Legierungen gegen Schwefel und eine neue schwefelbeständige Legierung.) F. Kanz. *Stahl und Eisen*, Vol. 50, Sept. 4, 1930, page 1272.

Abstract of an article in the 70th Anniversary Jubilee Publication for Wilhelm Heräus, pages 45–51 (Brune Claus, Hanau, 1930). The attack of sulphur on a group of alloys at higher temperatures was studied by heating samples in an electric furnace under an atmosphere of hydrogen which was removed by H_2S after reaching the test temperature. The time of sulphurization was one hour, the temperatures: 700°, 800°, 900° and 1000° C. The increase of weight is a means of measuring the attack of sulphur. Sulphur completely destroys pure nickel at 1000° C. Chromium increases their resistance to the attack of sulphur. An addition of 25% nickel to a 50% iron-25% chromium alloy does not improve the chromium-iron alloy. The only element which essentially improves nickel-chromium alloys is aluminum. The reasons for the favorable influence of aluminum are, according to the author, the raising of the melting point of the formed sulphur layer and the formation of a thin but gas-proof skin of alumina. The composition of this alloy is: Fe, 20%; Ni, 61%; Cr, 15%; Mn, 4%; Al, 10%. GN(4)

STRUCTURE OF METALS & ALLOYS (5)

Metallography & Macrography (5a)

Theory of Recrystallization of Pure Metals. (Zur Theorie der Rekristallisation reiner Metalle.) Ulrich Dehlinger. *Annalen der Physik*, Vol. 2, No. 7, Sept. 4, 1929, pages 749–793.

A theoretical discussion of recrystallization. In the author's theory, lattice particles from deformed zones serve as nuclei for new grains, mechanical deformation, therefore, being a prerequisite. Experiments showed that grain formation obeyed different time laws above and below the crystallization temperature. The various types of recrystallization structure and the mechanism of recrystallization are described for Al, Au, Cu, Ag. The following general rule may be stated: if a rolled plate in a deformed condition exhibits bent slip planes, it recrystallizes with a definite orientation and mechanical strength falls sharply. If no bending is observed before grain growth, the grains are without definite orientation. The occurrence and type of recrystallization, therefore, depend upon whether the elastic internal distortions at the instability point are still stable. With little rolling these distortions are generally not stable, but are with a high degree of rolling. Includes bibliography. (5a)

Structure of the Ferrous Metals. (La Structure des Metaux ferreux.) G. Delbart. *Aciers Speciaux, Mêtaux et Alliages*, Vol. 5, June 1930, pages 254–270; July 1930, pages 302–322, 2 references.

This was given as a lecture at the Institute of Applied Chemistry, Lille College of Science, France. First is considered the pure iron with its critical points and allotropic forms, which correspond with the microscopic examination, variation of the specific heat, electrical resistance and variation in the magnetism. Westgren and Phragmen on their X-ray studies of pure iron found the following:

Temperature	Allotropic form	Structure	Parameter
160° C.	α	body centered cube	2.87 A. U.
800° C.	β	body centered cube	2.90 A. U.
1100° C.	γ	face centered cube	3.63–3.68 A. U.
1425° C.	δ	body centered cube	2.93 A. U.

There is also considered the influence of carbon and other elements on the properties of iron. Critical points of iron-carbon alloy and Ni-Cr steel are given. GTM(5a)

Equilibrium Relations in Aluminum-Antimony Alloys of High Purity. E. H. Dix, Jr., F. Keller & L. A. Willey (Aluminum Company of America). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 356 (1930) 9 pages.

The aluminum rich aluminum-antimony alloys were studied by means of microscopic examination of heat treated samples, and a pyrometric determination of the eutectic temperature. The solid solubility of antimony in aluminum is less than 0.10%. A eutectic is formed at about 1.1% antimony, and the eutectic temperature is 657° C. Contains 6 references. JLG(5a)

Equilibrium Relations in Aluminum-Magnesium Silicide Alloys of High Purity. E. H. Dix, Jr., F. Keller & R. W. Graham (Aluminum Company of America). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 357 (1930) 15 pages.

High purity aluminum rich pseudobinary Al-Mg_2Si alloys were studied by microscopic examination of heat treated specimens and by thermal analysis. The solubility of Mg_2Si in aluminum was found to be 1.85% at the eutectic temperature and less than 0.27% at 200° C. The eutectic temperature is 595° C. Tensile tests indicated that the effect of artificial aging is most pronounced in alloys containing from 0.6 to 1.0% Mg_2Si. Contains 10 references. JLG(5a)

Distribution Equilibrium of Silver between Lead and Aluminum. A Test for the Distribution Law for Condensed Systems. (Das Verteilungsgleichgewicht von Silber zwischen Blei und Aluminium, ein Betrag zur Prüfung des Verteilungssatzes für kondensierte Systeme.) Richard Lorenz & Friedrich Erbe. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 183, Oct. 2, 1929, pages 311–339.

This is an example of a system in which 2 components are practically immiscible while the third is soluble to a high degree in the other 2 without affecting appreciably their solubility in one another. This mixture is studied over a wide range of concentrations at 750° and 1000°, and the distribution quotient is determined for both weight % and atomic %. The ternary diagram is plotted for the results obtained at 1000°. It is shown that van Laar's distribution law does not hold quantitatively, the failure being attributed to the lack of accurate values for van der Waal's constants. (5a)

Structure of Beryllium-Copper Alloys. (Zur Konstitution der Beryllium-Kupferlegierungen.) Georg Masing & Otto Dahl. *Wissenschaftliche Veröffentlichungen des Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 94–100.

The Be–Cu system up to 12% of Be has been re-examined by electrical conductivity and micrographical methods. At the peritectic temperature of 865° the solid solubility of Be in Cu is 2.8%; with decreasing temperature it falls to 1.72% at the eutectoid temperature, 578°, and to 0.75% at 400°. The $\alpha + \beta$ field extends from 2.8 to 4.3% of Be at 865° and from 1.72 to 6% at 578°, and the $\beta + \gamma$ field from 10.6 to 11% of Be at 910° and from 6 to 11% at 578°. Alloys containing the β phase undergo a eutectoidal transformation at 578° into $\alpha + \gamma$, which has typical pearlitic structure. The characteristic structures of numerous alloys are shown in photomicrographs. (5a)

The Diffusion of Zinc into Tin and Lead into Tin in the Liquid State. A Contribution to the Kinetics of the Soldering Process. (Ueber die Diffusion von Zink in Zinn und Blei in Zinn im flüssigen Zustand. Ein Beitrag zur Kinetik des Lötvorganges.) A. Merz & E. Brennecke. *Zeitschrift für Metallkunde*, Vol. 22, June 1930, pages 185–189; July 1930, pages 234–237, 23 references.

The importance of the rate of diffusion of the base metal into the liquid solder is emphasized. Diffusion equations are given and an apparatus for measuring the rate of diffusion and the method of carrying out measurements are described. It was established that in the systems solid Zn–liquid Sn and solid Pb–liquid Sn only dissolution and diffusion reactions take place. Liquid Sn on solid Cu forms Cu_3Sn below 420° C. which retards further reactions. The diffusion constants in the temperature range from 260–360° C. are determined for the systems Zn–Sn and Pb–Sn according to the method of Graham-Stefan. The temperature coefficient of the diffusion constants for Zn-Sn was determined between 260–370° C. and for Pb-Zn between 260–555° C. The diffusion constants are independent of the concentration within the range investigated. EF(5a)

Equilibrium Diagram of the Nickel–Chromium System. Seiji Nishigori & Matsujiro Hamasumi. *Kinzoku no Kenkyu*, Vol. 6 (1929) pages 219–225; *Science Reports Tohoku Imperial University*, Vol. 18, Dec. 1929, pages 491–502.

A simple eutectic exists in the Ni–Cr system, the eutectic temperature being 1320°, Cr 50%. The range of eutectic is 46–64% for Cr. From the extension of the liquidus, the melting point of pure Cr is 1650° or higher. The solid solution of Cr in Ni contains about 36% Cr, while the solution of Ni in Cr contains about 8% Ni. According to microscopic and X-ray examination Cr has no allotropic transformation, so the system has no eutectoid temperature. As etching reagent for the solid solution of Cr in Ni, concentrated HCl + $CuCl_2$ (saturated) was used; for the solid solution of Ni in Cr, concentrated HCl diluted by twice its volume of glycerol; and for the mixture of the 2 phases, 50% H_2SO_4 + a small quantity of H_3PO_4, heated on a H_2O bath. (5a)

On the Measurement of the Elastic Constant, Lattice Constant, and Density of Binary Alloys in the Range of Solid Solution. Z. Nishiyama. *Science Reports Tohoku Imperial University*, Vol. 18, Oct. 1929, pages 359–400.

The author has measured Young's modulus of elasticity, lattice constant and density of binary solid solutions. It was found that observed density agrees satisfactorily with that calculated from lattice constant. The relation of elastic constant to density, to hardness or to atomic volume is discussed. (5a)

The Importance of the Equilibrium Diagram. Remarks on the Paper by K. Honda on the Double Diagram of the System Iron-Carbon. (Die Bedeutung des Zustandsschaubildes. Bemerkungen zu dem Aufsatz von K. Honda: Ueber das Doppelschaubild des Systems Eisen-Kohlenstoff.) R. Ruer. *Stahl und Eisen*, Vol. 50, July 24, 1930, pages 1062–1067, 39 references.

Honda's scheme to simplify the iron-carbon diagram by omitting the equilibrium lines for graphite results from theories about the graphite crystallization which are contradictory to known test results. Honda's diagram must be completed by taking into account the graphite equilibrium. This is possible by considering the theory of heterogeneous equilibrium. The graphite lines can be drawn in the present diagram above the cementite lines. GN(5a)

The Formation of the β-phase of Silver-Zinc Alloys. (Zum Aufbau der β-phase von Silber-Zinklegierungen.) B. G. Petrenko. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 184, Nov. 18, 1929, pages 369–375.

Thermal analyses of Ag-Zn alloys of 30 to 44 weight % Zn content proved the existence of the intermetallic compound AgZn. This compound is not dissociated at its melting temperature. A temperature interval in the heating curves for an alloy of AgZn compound during the transformation of the β-phase to the β'-phase indicates partial dissociation of the compound at the transformation temperature. (5a)

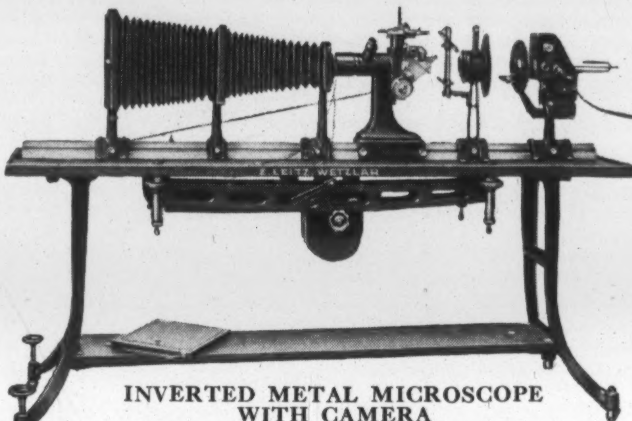
Structure of the γ-phase in the Alloys Silver-Zinc. (Zum Frage des Aufbaus der γ-Phase in den Legierungen Ag-Zn.) G. J. Petrenko & B. G. Petrenko. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 185, Dec. 10, 1929, pages 96–100.

The resistance diagram for alloys of Ag-Zn is constructed from measurements of the electric resistance of the alloys in the quenched condition. A maximum of resistance characterized the γ-phase. It is formed at the peritectic temperature of 665° according to the equation: β-mixed crystals with 45% Zn + melt with 49% Zn $\rightleftharpoons$ γ-mixed crystals with 47.61% Zn. The γ-phase has its transformation point at 225°; at lower temperatures it appears to be a chemical compound with the formula Ag_2Zn_3. (5a)

On the Thermomagnetic Property of Manganese. Y. Shimizu. *Kinzoku no Kenkyu*, Vol. 7, Aug. 1930, pages 447–450.

The transformations of manganese were observed by means of the measurement of the magnetic susceptibility. Very pure metallic manganese containing 99.9% was obtained by distilling the commercial metallic manganese under vacuum. The magnetic susceptibility obtained at room temperature is 7.55×10^{-6}, a value which is smaller than that obtained by previous investigators. The susceptibility begins to decrease over 300° C. but increases abruptly at 810° C. and 1100° C. which correspond to the transformations α (cubic system, a = 8.90 A. U.) to β (cubic, a = 6.288 A. U.) and β to γ (face-centered tetragonal, c/a = 0.940). The latter transformation is 3.8 times as large as the first one. KT(5a)

LEITZ . . .
MICRO-METALLOGRAPH
The Standard for Micro-Metalanalysis
MODEL 1931



INVERTED METAL MICROSCOPE WITH CAMERA
LEITZ Micro-Metallograph received the
"GRAND PRIX"
at International Foundry and Steel Exposition, Paris.

This **NEW MODEL** offers numerous features, some of which are: **MICROSCOPE** of especially heavy design//**MICROMETER SCREW** protected from heat rays//**INGENIOUS OPTICAL SYSTEM** creates a micro-image flat to the utmost edge, both for visual observation and photography//**PERMANENT ALIGNMENT** for coarse and fine adjustment//**IMPROVED ILLUMINATION** with conical and oblique light.

For use with the Micro-Metallograph we offer as a new feature an **AUTOMATIC DIFFERENTIAL DILATOMETER** which registers automatically as well as photographically the thermal changes of metals under temperatures approaching the viscosity border.

Another very important device for use with the Micro-Metallograph has recently been added and this is termed **DARKFIELD ILLUMINATOR;** this equipment affords an examination of metal specimens in an entirely new manner revealing a much clearer view into metal constituents than heretofore possible. The Darkfield Equipment is bound to cause considerable revolution in the present micro-metallographic testing methods.

WRITE FOR PAMPHLET NO. 1057 (MA)

E. LEITZ, INC.
60 EAST 10th ST., NEW YORK, N. Y.

BRANCHES:

Pacific Coast States: Spindler & Sauppe,
Offices at San Francisco and Los Angeles, Calif.

Washington District: E. Leitz, Inc.,
Investment Bldg., Washington, D. C.

Chicago District: E. Leitz, Inc.
122 So. Michigan Ave., Chicago, Ill.

AGENTS:

Pittsburgh District: Fisher Scientific Co.
Pittsburgh, Pa.

Canada: The J. F. Hartz Co., Ltd.,
Toronto 5, Canada

Transformation of Austenite at Constant Subcritical Temperatures. E. S. Davenport & E. C. Bain (United States Steel Corp., Research Laboratory). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 348 (1930) 30 pages.

Five carbon steels, 3 of which contained variable manganese, one low alloy steel and a stainless steel of the cutlery type were studied. Samples were rapidly cooled from above the upper transformation to definite temperatures below the lower critical point by quenching in lead or a lead-bismuth alloy maintained at the desired temperature. The rates of transformation at the temperature of the quenching bath were determined. Two methods were used in determining the rate of transformation; one suitable for temperatures above 300° C. consisted in quenching numerous samples at different time intervals and estimating the amount of untransformed austenite by microscopic study; the other, suitable for low temperatures, consisted in measuring the length change at the required temperature by means of an ingenious device and from this estimating the completeness of the transformation. In all of the carbon steels transformation was most rapid at about 540° C. Below this temperature the time required for transformation increased rapidly. In the range from Ac_1 to 500° C. the time of transformation appears to decrease with either increasing or decreasing carbon as it departs from the eutectoid. Manganese retards the transformation markedly. At lower temperatures both carbon and manganese definitely decrease the rate of transformation. The small amount of Cr in the low alloy steel (0.26%) retarded the reaction of the austenite. Hardness tests proved that in general the lower the transformation the greater the hardness. The structures resulting from transformations at various temperatures were determined and typical structures are shown. Contains 10 references.
JLG(5a)

Kinetic Measurement of a Transformation Reaction in the Solid State. (Kinetische Messung einer Umwandlungsreaktion in festen Metallen.) W. Fränkel & E. Wachsmuth. *Zeitschrift für Metallkunde,* Vol. 22, May 1930, pages 162–167, 7 references.

A 20% Al alloy of the Al–Zn system was investigated by the interferometer. Paper was presented before the Deutsche Gesellschaft für Metallkunde, Düsseldorf 1929. EF(5a)

A Contribution to the Hardening Problem of Cu-Ag, Be-Cu and Zn-Cu Alloys. (Beitrag zum Härtungsproblem von Kupfer-Silber, Beryllium-Kupfer und Zink-Kupfer-Legierungen.) M. Haas & D. Uno (Institut für Metallhüttenkunde & Elektrometallurgie, Technische Hochschule, Aachen). *Zeitschrift für Metallkunde,* Vol. 22, May 1930, pages 154–158, 18 references.

Curves of solid solubility were determined by measurements of electric conductivity and by dilatometry with rising and falling temperatures.
EF(5a)

The Utility of the Method of Electrical Conductivity for the Determination of the Constitution of Alloys. (Anwendungsbereich der Methoden der elektrischen Leitfähigkeit zur Bestimmung der Konstitution von Legierungen.) William Hume-Rothery. *Metallwirtschaft,* Vol. 8, Dec. 20, 1929, pages 1243–1246.

A discussion is given of the conditions under which the electrical conductivity method can be used in place of the customary thermal and microscopic methods for the determination of phase boundaries and transition lines. Particular cases are given in which the method may or may not be suitable. (5a)

Coarse Crystallization of Aluminum. (Die Grobkristallisation von Aluminium.) R. Karnop & G. Sachs. *Metallwirtschaft,* Vol. 8, Nov. 15, 1929, pages 1115–1118.

The temperature at which Al undergoes coarse crystallization is a function of the amount of cold deformation, the purity of the metal, and the nature of the impurities. Increased cold deformation decreases while the presence of impurities raises the temperature of coarse crystal formation. Si has a greater effect than Fe on raising the temperature of coarse crystallization.
(5a)

Aluminum and Its Formation of Solid Solution with Silicon. (Aluminium und seine Mischkristallbildung mit Silicium. Bemerkung zur gleichnämigen Arbeit von L. Anastasiadis.) W. Köster. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 181, July 6, 1929, pages 295–297.

Remarks pertaining to publication under the same title by L. Anastasiadis. The technic employed and the results obtained by the author in the determination of the temperature co-efficient of solubility of silicon in aluminum and in measuring electric resistance of aluminum are criticized. (5a)

A Contribution on the Constitution of the Fe–C–Si System. A. Kriz & F. Poboril. *Iron & Steel Institute, Advance Copy* No. 4, Sept. 1930, 20 pages.

Contains bibliography of 15 references. The Fe-rich alloys containing up to 6% Si, and from 0.1 to 4% C were investigated by thermal and microscopic methods. Sections of the ternary diagram are drawn, which show the eutectoid line, the solubility curve of C in gamma solid solution, and the transformation points. JLG(5a)

Extraordinary Crystal Growth in Iron and Copper. (Aussergewöhnliches Kristallwachstum an Eisen und Kupfer.) R. Kühnel. *Zeitschrift für Metallkunde,* Vol. 22, Feb. 1930, pages 53–55. Discussion.

Paper presented before the Deutsche Gesellschaft für Metallkunde, Sept. 1929. Reports on abnormal grain growth noticed in case-hardened steel, fire box copper and forging steel of about 0.3% C. Recrystallization due to long heating is supposed to be the cause. EF(5a)

Constitution and Formation of the Phosphide-Eutectic in Cast Iron. (Die Konstitution und Bildung des Phosphideutektikums im Gusseisen.) M. Künkele. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung,* Vol. 12, Report No. 145 (1930) pages 23–31; *Stahl und Eisen,* Vol. 50, August 21, 1930, pages 1207–1208.

The investigation was carried on as a result of discrepancies between former investigations. The difficulty in determining the constitution of the phosphide eutectic are due to the fact that its constituents can only be determined exactly when the eutectic has a coarse structure. Tests show that no difficulties are encountered when chromic acid is used as etchant and the samples are tempered after etching. The 3 constituents of a finely crystallized eutectic also show up in a different color after this treatment. The method was used for the examination of cast iron samples which contained partly ternary phosphide eutectic and cementite, partly phases composed of solid solutions and iron phosphide, thus giving the appearance of a "binary" structure. The formation of this pseudo binary eutectic, however, is contradictory to the phase rule. The constitution of the "binary" phosphide eutectic was studied with a cast iron C 3.27%, P 1.50%, Si 3.80% by quenching and thermal tests. The samples contained, above the crystallization temperature of the phosphide eutectic, a tenary, carbon bearing melt, whereas the eutectic crystallizing is composed of solid solutions of iron phosphide. The appearance of the structure depends largely on the crystallization velocity insofar as the crystallization of carbon is concerned (graphite or cementite). Iron-phosphorus-carbon alloys crystallize according to the stable system iron–iron phosphide–graphite (pseudo binary phosphide eutectic), as well as according to the metastable system iron–iron phosphide–cementite. Even a shift in the crystallization system from the stable to the metastable is frequently observed during the freezing. GN(5a)

Dilatometric Study of the Transformations and Thermal Treatments of Light Aluminum Alloys. (Étude dilatometrique des transformations et des traitements thermiques des alliages legers d'aluminium.) Albert Portevin & Pierre Chevenard. *Revue de Metallurgie,* Vol. 27, Aug. 1930, pages 412–435. 23 references.

A comprehensive study of the application of dilatometric methods for accurate thermal analysis and actual demonstration of the structural changes taking place in light aluminum alloys. Chevenard dilatometer was used, the sensitivity of which was increased by making the reference piece of 99.7% Al. Alloys were studied after different heat treating cycles. In Al-Si-Mg alloys solid solution of Mg_2Si is accompanied by contraction of the volume which is quite pronounced at 250°. On cooling its precipitation results in a certain expansion, but the precipitation is slow and incomplete. The behavior of a specimen in heat treating depends on the amount of Mg_2Si present in solid solution before the treatment. Taking of heating and cooling curves might result here in pseudo reversibility of the phenomena due to the opposite effects of quenching and drawing. The temperatures at which these cycles become pseudo-reversible are those which produce maximum softening after a given speed of quenching. The influence of small amounts of Fe and Mn (less than 1%) could not be detected dilatometrically. The mechanism of hardening of duralumin was studied with micro dilatometer (described) sensitive to 3×10^{-7} mm. Very good concordance between physical properties and dilatometric readings were observed. The speed of decomposition of Mg_2Si at a given temperature can be expressed by an equation:

$$\frac{\delta L}{L_0} = 27 \log (1 + 219t).10^{-6}$$

in which t represents time in hours. The speed of decomposition rapidly increases with the temperature, and the relation between the effects of different temperatures can be given by the expression

$$\frac{V_1}{V_2} = 2\,\frac{\Theta_1 - \Theta_2}{t}$$

where t is 10°. Between 20 and 100° the speed of reaction substantially follows the exponential law of the temperature doubling itself at the intervals of about 10°. In Cu alloys Al_2Cu acts very similar to Mg_2Si in the previous case. The curves begin to slope at 300° and become horizontal at 475° when the solution is complete. On cooling (at 200°/hr.) contraction takes place, but the precipitation is not complete. Tempering after quenching at the same temperature follows the same laws as for Al-Mg-Si alloys but in an inverse direction showing that it is accompanied by the diminution of expansion due to the return to the stable state of the supersaturated Al-Cu solution. Drawing these alloys after quenching at 525° for 8 hours indicated that the hardness increased, that the expansion of the solid solution was practically equal to that of pure Al and that the solution of Si in Al causes contraction. Under 100° the drawing action is very slight. Heating for 8 hours at 200–350 precipitates Si completely, but higher temperatures reduce the effect due to re-solution. The mechanism of quenching of Al-Si alloys is in complete agreement with the theories based on variations in solubility in the solid state. In Al-Cu (3.50–4.30% Cu) alloys a certain contraction takes place under 175° which cannot be accounted for by precipitation of Al_2Cu and cannot be satisfactorily explained. JDG(5a)

The Metallographic Structure of Hard Brass "Ms 58" after Different Heat Treatments. (Die Gefügeausbildung von Hartmessing Ms 58 nach verschiedener Wärmebehandlung.) P. Siebe & G. Elsner. *Zeitschrift für Metallkunde,* Vol. 22, April 1930, pages 109–114.

Experiments were carried out with 58% Cu brass containing 1.66–1.80% Pb from which the authors draw the following conclusions: End pieces of pressed bars tend to develop a gross macroscopic structure after being heated once to 800° C. The middle parts become coarsely crystalline if heated twice to 800° providing a rapid cooling followed the first heating. The length of time used for heating the brass to annealing temperature is of greatest importance for the formation of large grains. If the first anneal of a middle bar section is accompanied by slow bringing up to temperature and rapid quenching a coarse grain occurs after a second heat treatment, but the structure remains fine grained if the raise of temperature during the first heat treatment is a rapid one. The rate of heating up to temperature during the second heat treatment does not exert any influence. The thicker the bars the less the tendency of forming large β-crystals. However, the normal grain size of the latter is larger in case of smaller bar dimensions. The decomposition of the β-crystals under similar conditions always proceeds more in the end pieces than in the middle parts of the bar. Likewise the β-crystal decomposes more pronouncedly in heavy pieces than in light ones. The arrangement of the α segregation is governed by the lattice of the β-crystal. EF(5a)

The Metallographic Structure of Hard Brass "Ms 58." (Die Gefügeausbildung in Hartmessing Ms 58.) R. Hinzman & H. Flössner. *Zeitschrift für Metallkunde,* Vol. 22, April 1930, pages 115–118, 4 references.

Paper deals with experiments to determine the effects of various heat treatments upon the structure of a brass with 58% Cu and 2–3% Pb. Brass bars are submitted to several subsequent heat treatments in the mill which materially alter the microstructure and consequently influence the physical properties. Various interpretations regarding the appearance of the granular $\alpha + \beta$ structure exist. The authors arrive at the following conclusions: Three types of structure were found in Hard Brass Ms 58: (1) a needle shaped $\alpha + \beta$ grain produced by rapid air cooling from the β range. (2) a granular $\alpha + \beta$ structure which forms by slow cooling from the β range below the $\alpha - \beta$ line of solubility if the samples are held for a long period of time below the transformation curve. The α grains formed are rather large and exhibit no twinning. (3) a recrystallized, granular $\alpha + \beta$ structure formed by recrystallization and mechanical deformation of the α phase. In this case the α crystals are relatively small and show twin formation. Sufficiently long heat treatment above the $\alpha - \beta$ solubility curve will result in either acicular or granular $\alpha + \beta$ structure depending on the velocity of cooling down.
EF(5a)

The System: Copper–Oxygen. (Ueber das System Kupfer-Sauerstoff.) R. Vogel & W. Pocher. *Zeitschrift für Metallkunde,* Vol. 21, Oct. 1929, pages 333–337; Nov. 1929, pages 368–371, 18 references.

Alloys of Cu and Cu_2O were prepared and analyzed thermally. The eutectic arrests were extrapolated which show a low solid solubility. It was observed that small amounts of oxygen in cast electrolytic copper exhibit dendritic formation and coring indicating the formation of solid solutions on etching with copper ammonium chloride. A cast sample which showed the eutectic with coring and which revealed a slight eutectic arrest, exhibited very little eutectic after being annealed at 950° C. for 16 hours. In the same fashion the solubility of oxygen in copper was determined, strengthened by oxygen determinations after the anneal, yielding a solubility of 0.8% Cu_2O at the eutectic temperature. The results are plotted in a diagram. Cu, melted in oxygen, exhibited zoning which could be overcome by reduction with hydrogen. An increase of hardness was noticed in the saturated solid solution. Thermal analyses were made on alloys up to 18% oxygen. The melting point of Cu_2O, which is not stable at low temperatures, decomposing into a solid solution of oxygen in copper and CuO, was found at 1230° C. At 1195° an immiscibility gap was established between 15% Cu_2O and 95% Cu_2O. The decomposition of Cu_2O, which could not completely be brought to an end after 40 hours at 300°, is too slow to be noticed on a cooling curve. The transition point occurs around 375° C. The results are presented in diagrams. EF(5a)

Dilatometric Anomalies of Several Extra Mild Steels after Special Heat Treatment. (Anomalies dilatométriques de quelques aciers extra doux apres un chauffage spécial.) J. Seigle. *Génie Civil*, Vol. 95, Oct. 12, 1929, pages 359–361.

Gives normal dilatometric curves for mild and extra mild steels together with the results of tests of Armco steels by the American Rolling Mill Company. Tests of electric steels and possible causes of anomalies are observed and the influence of dissolved gases noted. (5a)

The Formation Heat of Cementite. (Die Bildungswärme des Zementits.) T. Watase. *Zeitschrift für physikalische Chemie*, Vol. 6, May 1930, pages 390–395.

The values of the formation heat of Fe_3C available at the present time fluctuate between +8.9 and −15.4 kcal. The author redetermined this value by combusting cementite free from gases under additions of benzoic acid and sugar and carefully analyzed the combustion products in the calorimeter. The determination of the formation heat from α-iron and β-graphite yielded −2.5 kcal. which value is in fair agreement with that found by Roth amounting to −3.9 kcal. EF(5a)

Structure & X-ray Analysis (5b)

Molecular or Atomic Solid Solution of a Metallic Compound in the Matrix. (Zur Frage der molekularen oder atomaren festen Lösung einer Metallverbindung im Grundmetall.) G. Wassermann (Kaiser Wilhelm Institut für Metallforschung, Berlin-Dahlem). *Zeitschrift für Metallkunde*, Vol. 22, May 1930, pages 158–160, 13 references.

Problem is attacked by X-ray examinations of Mg-Zn alloys. EF(5b)

Application of X-Rays to Development Problems Connected with the Manufacture of Telephone Apparatus. M. Baeyertz (Western Electric Co.). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 349 (1930) 14 pages.

From information gained from radiographing die castings the dies have been modified to yield castings substantially free from porosity. Radiography has also been applied successfully to the study of crystal size and unsoundness in copper wire bars. An example of the industrial use of X-ray diffraction is given in its use in distinguishing between satisfactory and unsatisfactory condenser foil. Contains 2 references. JLG(5b)

X-Ray Analysis in Foundry Practice. (Röntgentechnik in der Giesserei.) W. B. Bartels. *Giesserei Zeitung*, Vol. 26, Nov. 1929, pages 632–634.

Contains notes of the application and advantages of X-ray analysis of castings; considerations of cost; details of chemical and physical crystallography. Five fundamental possibilities of fine structural analysis are enumerated. (5b)

Materials Testing with X-Rays at the Foundry Technical Exhibition at Düsseldorf. (Die Werkstoffprüfung mit Röntgenstrahlen auf der Fachausstellung in Düsseldorf.) R. Berthold. *Giesserei Zeitung*, Vol. 26, Oct. 1, 1929, pages 555–559.

Gives a review of exhibits of methods and apparatus of X-ray analysis, from which the impression is gained that the analysis of the structure of metals has become a valuable testing medium in many works. There were no outstanding improvements in X-ray apparatus. (5b)

The Various Types of Zirconium Oxide in Relation to the Preceding Treatment. (Die Formen des Zirkondioxyds in Abhängigkeit von der Vorbehandlung.) W. M. Cohn & S. Tolkstorf. *Zeitschrift für physikalische Chemie*, Vol. 6, July 1930, pages 331–356. 14 references.

Three allotropic modifications of ZrO_2 are established by X-ray examination and compared with the analogous oxides of Si and Ti. EF(5b)

X-Ray Investigation of the Age Hardening Process in Beryllium-Copper Alloys. Otto Dahl, Else Holm & Georg Masing. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 154–186.

The face-centered cubic lattice of Cu contracts progressively to a maximum of about 3% by the introduction of Be, the supersaturated α phase with 2.5% of Be having a lattice parameter of 3.564 A. U. compared with 3.619 A. U. for pure Cu. The γ-phase has a body-centered cubic lattice of the Cs chloride type with a parameter 2.70 A. U.; the Cu and Be atoms are regularly distributed, so that the γ-phase consists of the compound CuBe. On aging at 150° the supersaturated α alloy with 2–2.5% of Be, the (331) line begins to become diffuse after 4 hours; this is attributed to the commencement of the precipitation of γ. At 350° the γ-phase can be recognized in the röntgenograms after a few minutes heating; at the same time the α lines become less sharply defined. Prolonged aging at 150–250° causes the α-lines to become much more diffuse than can be attributed to the separation of γ; this increased diffuseness is ascribed to the generation of internal stresses owing to the formation of numerous γ-nuclei. The aging of wires drawn after quenching is much accelerated. The wires have a fibrous structure characteristic of a face-centered lattice structure; on aging, the γ crystals also have a fibrous structure with the (110) direction in the axis of the wire. 22 references. (5b)

X-Ray Investigation of Copper Amalgams. (Röntgenographische Untersuchung der Kupferamalgame.) Nobuyuki Katoh. *Zeitschrift für physikalische Chemie*, Vol. 6, Abt. B, Nov. 1929, pages 27–39.

Amalgam prepared by electrolysis and pressed under 10,000 kg./cm.^{2} analyzed 25.5% Cu. This gives a powder spectrum similar to the γ-phase of brass, with a cell constant of 9.401 ± 0.005 A. U. The limits of homogeneity in this phase lie between 24.1 and 29.9% Cu. In amalgams richer in Cu there occur at room temperature 2 phases, the γ-phase and an α-phase which has the Cu lattice with unchanged constant. (5b)

The Structure of the Spectra of Doubly and Trebly Ionized Zirconium. C. C. Kiess & R. J. Lang. *Bureau of Standards Journal of Research*, Vol. 5, Aug. 1930, pages 305–324.

The spectra emitted by Zr atoms which are doubly and trebly ionized have been observed with the grating and prism spectrographs of the National Bureau of Standards and with the vacuum grating spectrograph of the University of Alberta. These spectra have been analyzed and the series relationships involved in them have been established. The terms which have been found to account for the spectra are without exception those required by the quantum theory. Zr IV is a doublet spectrum which results from the migration of a single electron which, in its unexcited state, occupies a 4_3 orbit. From a series of S terms an ionization potential of 33.83 volts is derived, corresponding to a value of 274,067 cm.$^{-1}$ for the lowest term $4^2D_{3/2}$. Zr III consists of singlet and triplet systems, the terms of which result from the interaction of 2 electrons occupying 4_3 orbits in their unexcited state. Sequences of ^1D and ^3D terms have been found which result when one of the electrons occupies an n_1 orbit, the other remaining in a 4_3 orbit. These term sequences place the ground term, $^3F_2$, at 194,441 cm.$^{-1}$, which gives 24.00 volts as the ionization potential of Zr^{++}. Among the Zr III multiplets are those representing the transition $4f \longrightarrow 4d$. These multiplets and also those representing intersystem combinations exhibit anomalous intensities. (5b)

X-Ray Tests of Welds. H. H. Lester. *Army Ordnance*, Sept.-Oct. 1930, pages 124–127.

Technique developed at Watertown Arsenal discussed. (5b)

The Structure of Metals. (Ueber den Aufbau der Metalle.) V. Dehlinger. *Metallwirtschaft*, Vol. 9, July 11, 1930, pages 589–592.

Contains 9 references. Discusses the accepted theories and the author's own ideas on the relation between atomic structure and the physical properties of metals, the arrangement of protons and electrons, study by X-rays, difference in properties of metals and non-metals, etc. CEM(5b)

Radiographic Analysis of Metals Suitable for Stressed Parts. W. L. Fink & R. S. Archer. *Automotive Industries*, Vol. 61, Oct. 19, 1929, pages 571–574.

A description of X-ray laboratory installed at the new foundry of the U. S. Aluminum Company at Fairfield, Conn. See *Metals & Alloys*, Jan. 1930, page 339, "Radiography as a Tool in the Metal Industry." (5b)

Constituents of Aluminum-Iron-Silicon Alloys. William L. Fink & Kent R. Van Horn (Aluminum Company of America). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 351 (1930) 11 pages.

The phases present in the system were studied by X-ray diffraction methods. The compound $FeAl_3$ was identified. α(Fe-Si) appears identical with $FeAl_3$, except for a slight contraction of the lattice, and is probably a solid solution of silicon in $FeAl_3$. β(Fe-Si) gives a pattern entirely different from any other constituent in the system. For the alloys investigated its parameter did not vary. Contains 6 references. JLG(5b)

Arrangement of the Micro-Crystals in Compressed Single-Crystal-Plates of Al. II. Yoshio Fukami. *Memoirs of the College of Science, Kyoto Imperial University*, Series A, Vol. 13, No. 3, May 1930, pages 229–237.

When a single-crystal-plate of aluminum is compressed, the micro-crystals produced by the destruction of the single crystal rotate themselves in such a way that their (110) planes, which make the slightest inclination to the flat surface of the specimen, become nearly parallel to the flat surface by taking 111, 110 or 112 axis which is nearly parallel to the flat surface of the specimen, as the axis of rotation. The relation between the maximum angle of rotation of micro-crystals and the reduction of thickness of the specimen was investigated, and it was found that the maximum angle of rotation takes the maximum value at a reduction of about 30–50% in the thickness of the specimen. As the scattering of the orientation of the micro-crystals is affected by the manner of flow of the metal by compression, the relation between the scattering of the orientations of the micro-crystals and the manner of flow of the metal was also examined with specimens having various different shapes. When the specimen in the form of a circular plate is compressed beyond 70% reduction in thickness, the micro-crystals begin to rotate themselves around the crystallographic 110 axis which is perpendicular to the flat surface of the specimen. (5b)

X-Ray Investigation of the Iron Nitrides. (Röntgenuntersuchung über die Nitride des Eisens.) G. Hägg. *Zeitschrift für physikalische Chemie*, Vol. 6, July 1930, pages 455–474.

Iron nitrides prepared by treating pure Fe with ammonia were submitted to X-ray examination. At higher temperatures, i. e., above 600° C., nitrogen dissolves in α-Fe enlarging the space lattice. The largest length of the body centered cell of α-Fe was determined to 2.871 A. U. Samples containing 1.5–2.0% N_2 by weight mainly consisted of γ-Fe in which nitrogen is dissolved, if quenched from 725° C. A maximum length of the γ-Fe unit cell was measured to be 3.638 A. U. The first intermediate phase (γ) has a very narrow range of homogeneity below 600° C. approaching the composition Fe_4N. The iron atoms form a face centered cubic lattice. The cube length increases in this homogeneity range from 3.787 to 3.790 A. U. and becomes wider toward the iron side at higher temperatures. In the next phase, ϵ- between 8 and 11% N_2—the atoms are arranged in the hexagonal close packed manner with the following length of the unit cell at the border lines:

a = 2.695 c = 4.362 A. U.
a = 2.767 c = 4.417 A. U.

A further phase, the richest in nitrogen, was found to have a basic centered rhombic lattice with the following dimensions: a = 2.758, b = 4.819, c = 4.419 A. U. The border line toward the iron side approaches the composition Fe_2N. A schematic constitutional diagram Fe-N is outlined and the microstructures after treating with ammonia are discussed. 12 references EF(5b)

X-Ray Investigations of the Molybdenum and Tungsten Nitrides. (Röntgenuntersuchungen über Molybdän- and Wolframnitride.) G. Hagg (University of Stockholm). *Zeitschrift für physikalische Chemie*, Vol. 6, April 1930, pages 339–362, 14 references.

An X-ray study was made on W and Mo-nitrides which were prepared by treating the pure metals with ammonia. A solubility of nitrogen could not be observed in either metal. In Mo–N system the β-phase, poorest in nitrogen, is homogeneous at 28 atomic % nitrogen but exists only at temperatures higher than 600° C. The Mo atoms of this phase are arranged in the face centered tetragonal lattice. The next phase, γ, is homogeneous at about 33 atomic % nitrogen showing a cubic closest packed lattice. It is possible that both phases are connected at higher temperatures. The similarity of these phases to the δ and ϵ-phase in the Mn-N system is discussed. The phase highest in nitrogen is located at 50% N in which the metal atoms form a simple hexagonal lattice. The structure of this phase is analogous to the phase in the system W–C containing 50 atomic % carbon. The only phase, β, which could be secured in the W–N system is probably homogeneous with about 33 atomic % nitrogen and corresponds to the γ-phase of the Mo–N system of the same concentraton. It forms a lattice of cubic close packing. EF(5b)

The System: Copper–Zinc. (Das System Kupfer-Zinc.) Rudolf Ruer & Karl Kremers. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 184, Nov. 7, 1929, pages 193–231.

The *l*- and *s*-curves in the system Cu–Zn were redetermined, the *s*-curves being calculated with the aid of heating curves. The solidification intervals of the α-series and especially of the β-series of solid solution was found to be much smaller than expected. A homogeneous solidification at constant temperature of 2 melts was found with the concentrations 62.1% Cu and 40.2% Cu. The transformations which take place in the β-series of solid solutions was studied by means of heating and cooling curves. Only one transformation $\beta \rightleftharpoons \beta''$ takes place at 444° in the concentration range from 61 to 55% Cu; a double transformation $\beta \rightleftharpoons \beta' \rightleftharpoons \beta''$ was found at 464 and 454° with compounds from 51 to 43% Cu. The average specific heats were determined for Cu, Zn and a number of compounds between 80 and 45% Cu at temperatures ranging from 850 to 200°. The transformation energy which is liberated during cooling can be calculated for every temperature from the specific heat. The maximum transformation heat was found with 51.81% Cu; this compound was studied with special care. Its thermal behavior showed that the transformation of the β-brass cannot take place in one homogeneous phase, but that a new phase appears. The thermal behavior of Fe at the temperature of its magnetic transformation is very similar. A change of the space lattice at the transformation temperature cannot be observed in either case. According to the diagrams of the melts and the properties of the different compounds two Cu-Zn compounds were detected, the first one with 40% Cu in the γ-field and the second with 51% Cu in the β-field. The formula for the first one is either Cu_2Zn_3 (39.32% Cu) or $Cu_{21}Zn_{31}$ (39.70% Cu). The latter agrees better with the space lattice of the γ-brass. The formula for the second compound is $Cu_{14}Zn_{13}$ (51.14% Cu) when the space lattice of the β-brass is taken into consideration. (5b)

Studies upon the Widmanstätten Structure. I. Introduction. The Aluminum-Silver System and the Copper-Silicon System. Robert F. Mehl & Charles S. Barrett (Naval Research Laboratory). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 353 (1930) 35 pages.

The results of former investigators of Widmanstätten structure are critically reviewed. This structure occurs not only in iron-carbon alloys and in meteorites, but in numerous other alloy systems. The Widmanstätten structure is formed by the precipitation of a solid phase from a solid phase. In meteorites kamacite is precipitated from taenite, and in hypo-eutectoid steels ferrite is precipitated from austenite. In both of these instances the separating phase is formed in plates along the octahedral (111) planes of the parent phase. The precipitation of the γ-phase from the δ solid solution in aluminum-silver alloys was experimentally investigated. A 21.3% silver alloy was treated to yield a coarse Widmanstätten structure. In this alloy the δ-phase has a face centered lattice whose dimensions are indistinguishable from those of aluminum, and the γ-phase has a hexagonal lattice. The plates of γ were found to form on the (111) planes of the δ solid solution, and were so oriented that the basal (001) plane is parallel to the (111) plane of the parent lattice. This is the orientation that necessitated the least rearrangement of the atoms. The copper-silicon alloys containing the Widmanstätten structure were also studied. In this system the γ-phase precipitates in plates parallel to some crystallographic plane, but not the (111) plane, as there are 12 families of equivalent planes instead of the 4 possible for separation along the (111) planes. The indices of the planes could not be determined. It is suggested that the Widmanstätten structure need not be formed of plates, for true needles or other figures sometime occur. It is tentatively proposed that a new plane appearing by precipitating from a solid solution separates in such a manner that some crystallographic feature in the new lattice forms directly with only a small shift in the nearly identical crystallographic feature in the parent lattice. The behavior of Cu-Si and Fe-N alloys prove that separation of a precipitate from a solid solution does not always occur on the plane of greatest atomic density. Contains 41 references. JLG(5b)

The Examinations of Welds by the X-Ray Diffraction Method. John T. Norton (Massachusetts Institute of Technology). *Journal American Welding Society*, Vol. 9, Sept. 1930, pages 11–19.

Report rendered to Fundamental Research Committee of the American Bureau of Welding. Describes in some detail the "pin-hole" method for the study of granular structure. A narrow beam of X-rays defined by small holes in lead diaphrams passes through thin sample of metal and falls upon a photographic plate. After suitable exposure, the developed plate will contain a dark spot due to the direct beam and certain rings or dark spots which are dependent upon the structure of the sample. Illustrations are given showing usefulness of this method in studying weld made by the metallic arc process in aluminum sheet. LFM(5b)

X-Ray Investigation of the Iron-Manganese System. (Röntgenographische Untersuchungen über das System Eisen-Mangan.) E. Oehman. *Zeitschrift für physikalische Chemie*, Vol. 6, Sec. B, June 1930, pages 81–110, 18 references.

The binary constitutional diagram Fe-Mn was re-established based on X-ray examination. The existence of a stable intermediate phase could not be proven. The range of homogeneity of the α- and γ-Fe phase and of the α, β and γ-Mn phase was determined. The face centered cubic γ-Fe phase and the face centered tetragonal phase of γ-Mn probably form a continuous range of solubility. A miscibility gap around 70% Mn may, however, exist. The solubility of iron in β-Mn increases from 0% at 1191° (the transformation point of γ-Mn into β-Mn) to about 35% at 730° C. The transformation line of β-Mn to α-Mn is practically not effected by iron. The solubility of Fe in α-Mn is only influenced to a small extent by the temperature. An appreciable increase of volume accompanies the transformation β-Mn to α-Mn in contrast with the transformation γ-Mn to β-Mn. The existence of a hexagonal close packed ϵ-phase was confirmed which is unstable and which could only be preserved by rapid quenching. On the strength of X-ray photographs at elevated temperatures the proof was furnished that the ϵ-phase is not stable at temperatures above 500° C. The appearance of ϵ interferences in X-ray photograms of quenched alloys is discussed. The transformation γ-Fe into the ϵ-phase is accompanied by a large decrease of volume. The solubility of Mn in α-Fe is only very small. EF(5b)

The Determination of Crystallite Orientation. G. Tammann. *Institute of Metals, Advance Copy* No. 538 (1930) 45 pages.

The orientation of metal crystals may be determined by (1) pressure figures or slip lines on individual grains, (2) the process of etching and tarnishing, (3) X-ray measurements. Method (1) is applicable to only rather large crystals. The figures produced by this method are decreased in detail. Method (2) the "etching-glitter" method is applicable to all but the most minute crystals. Results obtained by X-ray method of study are in general agreement with results obtained by X-ray methods. In copper 3 stages may be distinguished during cold working. In the first stage the octohedral planes on the rolling plane increase in number; in the second, dodecahedral planes increase; and in the third stage the crystallites are broken into narrow strips with adjacent strips in the twinned position and the etched furrows at 35° to the direction of rolling. In aluminum the process of deformation differs in that the second stage does not start below 90% reduction and the third stage is never reached. In iron, slip occurs with simultaneous formation of twin lamellae on the icositetrahedral planes. In the first stage the cubic planes increase in number, in the second stage the octohedral planes and the third stage is not found. When cold worked samples are heated, the crystallite orientation does not change even after recovery of the original physical properties. For iron, the structure formed by cold rolling persists until the transformation into γ-iron. Complete restoration is not brought about by annealing under 1000° C. For cold worked copper a temperature of 800° C. is necessary to restore random orientation. At higher temperatures the number of cubic faces parallel to the rolling surface becomes abnormally large. In castings of copper and iron the columnar crystals in the surface layers are oriented so that the cubic planes are parallel to the surface. In aluminum and nickel, where the rate of cooling is greater the icositetrahedral and octahedral plane tend to form parallel to the surface. The sizes of grains in the center of a cast metal tend to fall on a Gauss error curve. The vibration figures produced on discs cut from rolled sheets are discussed. Contains 55 references. JLG(5b)

Cemented Tungsten Carbide. A Study of the Action of the Cementing Material. L. L. Wyman & F. C. Kelley (General Electric Co.). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 354 (1930) 21 pages.

In order to determine the action of cementing compounds in tungsten carbide alloys a series of alloys ranging from almost pure tungsten carbide to cobalt were prepared and given the standard sintering treatment of 1400° C. for 1$^1/_2$ hours. Microscopic examination showed that tungsten carbide dissolved in the cobalt, and that the binding material in the commercial alloys is probably a solid solution of WC in cobalt. The tungsten carbide particles were found to grow at the sintering temperature, and with sufficient cobalt to form very regular crystals from the irregular particles produced by grinding. With large percentages of cobalt dendrites and eutectic structures were formed. At the sintering temperature the binding material is liquid. X-ray studies indicated that the cobalt lattice was expanded, even at low carbide concentrations. JLG(5b)

Physics and Physical Metallurgy. (Physik und Metallkunde.) W. Rosenhain *Zeitschrift für Metallkunde*, Vol. 22, March 1930, pages 73–78.

Recent advance in physics and importance of metals in experimental physics are considered in the introduction and the inner structure of metals and alloys are discussed from the view-points of Rosenhain's lattice distortion theory, with emphasis on the color of metals and solid solutions. Allotropic modifications of metals are considered at the hand of α and γ manganese and the assumption of "loose atoms" and molecules in metals is introduced. RF(5b)

PHYSICAL, MECHANICAL & MAGNETIC TESTING (6)

Dynamic Strain-Hardening and Overload Capacity of Steels. (Ueber Dynamische Verfestigung und Ueberlastungsfähigkeit von Stählen.) A. Thum & W. Wiss. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 14, 1929, pages 1787–1788.

Excerpt from the doctor thesis presented by Wiss to the Technische Hochschule Darmstadt. It contains a report of experiments on the dynamic behavior of steels under varying repeated stresses and with pre-stressed material. The tests permit important conclusions with regard to the influence of cold-working. The original must be referred to for details. Ha(6)

Magnetic Measurements on Beryllium-Iron Alloys. (Magnetische Messungen an Eisen-Berylliumlegierungen.) O. v. Auwers. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 236–247, 9 references.

The article gives the results of measurements made on alloys containing iron as the base metal with varying amounts of Be from 0.5–4.0%. For comparison purposes measurements on the following alloys are included: Fe 98%, Be 1%, C 1%; Fe 97%, Be 1%, Si 2%; Fe 97%, C 1%, Si 2%; and Fe 96%, Si 4%. (6)

Brinell Hardness, Penetration and Pendulum Hardness of Various Light Metal Alloys. (Brinellhärte, Eindringtiefe und Pendelhärte bei verschiedenen Leichtmetall-Legierungen.) Franz Bollenrath. *Metallwirtschaft*, Vol. 9, July 25, 1930, pages 625–629.

Control tests to check the quality of Al and Mg for aircraft are important. The Brinell hardness test is used mostly in other industries. In production tests the reading of Brinell impressions becomes hard on the eyes, and this method cannot be used for thin sheets. Better methods for thin light alloy sheets are the Rockwell tester, the Martens scratch test and the Herbert pendulum. The scratch is suitable for laboratory investigation but not for shop tests. The Herbert pendulum can be used on light alloy sheets down to 0.3 mm. thick and on hardened steel sheets down to 0.13 mm. thick. A comparison between these tests and Brinell numbers is desirable because Brinell numbers are well known and other physical properties can be calculated from them. Theoretical relations do not check actual results and the relations differ with different chemical composition, heat treatment and cold working. Tests were made by 4 different methods on 6 materials in order to obtain separate conversion tables and curves for each material. Those tested were: Duralumin 681B, VLW1 (Lautal), VLW3 (Silumin), U11 (Ultralumin), AZM and AM503 (Elektron). In the Brinell tests a 2.5 mm. steel ball with 62.5 kg. load, applied at least 30 seconds, was used. In the Rockwell test the $^1/_8$'' and $^1/_{16}$'' steel balls with 100 kg., in the Testor test a 2.5 mm. steel ball and 62.5 kg. load and in the Herbert test the 1 mm. steel and diamond balls were used with 10–20 single swings. Test pieces 1.5–2 mm. thick were given various heat treatments to obtain different degrees of hardness. Curves for each of the 6 materials are given, the other 3 hardness tests plotted against Brinell. They are considered accurate within 7%. The curves differ somewhat for the 6 materials. CEM(6)

Development of Casing for Deep Wells. F. W. Bremmer (Spang, Chalfant and Co.). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 355 (1930) 16 pages.

To select a type of steel suitable for deep well casing 6 different types were melted in an electric furnace and made into seamless tubing. One steel contained 0.19% carbon and 2.65% manganese. The others contained approximately 0.30% carbon, one contained manganese and molybdenum, one silicon and manganese, one silicon, manganese and chromium, one nickel and molybdenum, and the other chromium and molybdenum. The steel containing 2.65% manganese was brittle and could not be threaded in the automatic machines. The manganese silicon steel had only fair ductility. Tensile tests on the other steels after rolling, normalizing and heat treating showed no marked differences between the 4 different compositions. The Si-Mn-Cr steel was selected as being the most suitable for high strength tubing—the cost was a factor. High strength tubing is now regularly produced from a steel of 0.40% C, 1.10% Mn, 0.25% Si and 0.18% Cr. The average of 200 tensile tests of samples from this tubing were: 107,500 lbs./in.^{2} tensile strength, 64,750 lbs./in.^{2} yield point, 25% elongation, 43% reduction of area. JLG(6)

Stamping Tests of Sheets. (Les Essais d'emboutissage des toles.) R. Cazaud. *Aciers Speciaux, Mêtaux et Alliages*, Vol. 5, Jan. 1930, pages 6–14, 3 references.

A description of various types of apparatus used for stamping. Persoz introduced his apparatus for testing sheet in 1910, Pitoits machine in 1924, Erichsen, Guillery and Avery later. Stamping tests can be used to control the annealing temperatures of sheets. Curves are given showing the relation between the stamping and the thickness of the steel. GTM(6)

The Determination of Elongation of Solid Materials by Means of Mechanical and Photographic Recording Methods. (Ueber die Vornahme von Ausdehnungsmessungen an festen Korpern mit Hilfe von mechanischer und photographischer Registriermethoden.) Willi M. Cohn. *Chemische Fabrik*, Vol. 3, July 2, 1930, pages 257–259.

Contains 33 references. A review of mechanical and photographic devices for recording elongation of metals during tension and long time tests. A new photographic device developed by the author is described in detail. It can be used in tests up to 1400° C. It is of simple construction and requires very little attention during the test. CEM(6)

Role of the Conduction Electrons in Ferromagnetism. (Die Rolle der Leitungselektronen beim Ferromagnetismus.) J. Dorfman, R. Jaanus & I. Kikoin. *Zeitschrift für Physik*, Vol. 54, April 4, 1929, pages 277–296.

Investigation is directed to the question whether, in ferromagnetic metal, conduction electrons or electrons bound to positive ions of metal, play the role of elementary magnets. (6)

On the Influence of the Rolling Process, Especially in Rolling within the Critical Temperature Range on the Notch Toughness of Steel. (Ein Beitrag zur Frage des Einflusses des Walzens, besonders im kritischen Temperatur gebiet, auf die Kerbzähigkeit von Flussstahl.) J. Feilen. *Archiv für Eisenhüttenwesen*, Vol. 4, July 1930, pages 37-40; *Stahl und Eisen*, Vol. 50, Aug. 7, 1930, page 1138. 10 references.

The unfavorable influence of rolling within the critical temperature range between 800° to 850° C. on the notch toughness of soft steels increases with the degree of deformation. The influence of the temperature was determined in 3 test groups for rolling speeds of 2, 3.7 and 6 m. per second. 800 samples were taken for notch toughness tests and tested in a 75 kg. Charpy machine. The notch toughness is generally not impaired in rolling within the critical temperature range for reductions up to 40%. GN(6)

The Fatigue of Metals. (La Fatigue des Métaux.) R. Cazaud. *Aciers Speciaux, Métaux et Alliages*, Vol. 4, July 1929, pages 322–331; Aug. 1929, pages 361–370; Sept. 1929, pages 423–428.

A review. Includes bibliography. (6)

An Investigation of the Magnetic and Electrical Properties of Some Iron-Chromium Alloys. F. K. Fischer. Thesis for E.E. degree. *Rensselaer Polytechnic Institute Bulletin, Engineering and Science Series*, No. 28, June 12, 1930, 32 pages.

Electrical resistivity and magnetic properties were determined on alloys made up for 10, $12^1/_2$, 15, $17^1/_2$, $18^3/_4$ and 20% Cr, balance iron, and on those for 5% Ni, 16.6% Cr, and 10% Ni, 15.8% Cr, balance iron. The raw materials were Armco iron, 97.75% chromium containing 0.3% C, 0.4% Si and electrolytic nickel. Carbon was not determined in the final alloys nor are their exact analyses given. The 17.5 to 18.7% Cr alloys have zero magnetostriction and this fact is thought to be related to the fact that fairly good magnetic properties were found in those alloys though they are inferior to iron silicon alloys, for example. The effect of annealing, quenching and baking at 500° C. after annealing was studied. The best alloy was that of 18.7% Cr which has about $^1/_3$ the permeability and 4 times the hysteresis loss of Armco iron.

The 50% Ni, 16.6% Cr alloy was too hard to machine. The 10% Ni, 15.8% Cr was found to be non-magnetic, and this fact is stated to be "unexpected." No correlation of the magnetic properties with the ternary equilibrium diagram was attempted and no attention paid to the microstructure of the alloys. HWG(6)

Tests of Stability of Hysteresis of Iron Nickel-Alloys. (Versuche über die Stabilität der Hysteresis Fe-Ni-Legierungen.) G. Gossels. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 182, Aug. 7, 1929, pages 19–27.

Gives results of experimental study made in the Metallurgical Laboratory of the Technische Hochschule Charlottenburg. Resistance isotherms for temperatures of 0° to 900° C. and nickel content up to 46% are given. (6)

Hardness Tests of Steel Strips. G. A. Hankins. *Engineering*, Vol. 130, Sept. 12, 1930, page 324.

Letter commenting on tests made at the National Physical Laboratory. Table is given showing results of series of tests in a Vickers machine using steel strip 0.0152 in. in thickness. Results show that maximum load should be about 15 kg. when accuracy is required. Other tests were carried out on piece of hardened and tempered Cr-V steel which showed that minimum permissible thickness is about 0.9 mm. for 100 kg. test load. Minimum thickness of $1^1/_2$ times the diagonal of the impression is indicated for 136° diamond pyramid hardness tests. LFM(6)

The Effects of Two Years' Atmospheric Exposure on the Breaking Load of Hard-Drawn Non-Ferrous Wires. J. C. Hudson (British Non-Ferrous Metals Research Association). *Institute of Metals, Advance Copy* No. 541 (1930) 14 pages.

The tests were made at South Kensington and included 20 different materials. Some of the materials were high conductivity copper, silicon copper arsenical copper, nickel copper, cadmium copper, two bronzes, 70–30 brass, copper-nickel alloys containing from 15–70% nickel, zinc and galvanized iron. The losses in strength were very small, and were in general agreement with results of earlier work in which the corrosion effect was determined by loss in weight. Contains 5 references. JLG(6)

The Strength of Welded Bull Plugs. C. L. Hughes. *Mechanical Engineering*, Vol. 52, Oct. 1930, pages 911–914.

The 2 types of welded heads which are widely used in closing the ends of small pressure vessels have been investigated. These 2 types are the orange-peel head and the bonnet head. Descriptions are given of the test apparatus, tests on elastic behavior and rupture tests. In general, the results show that under similar conditions an orange-peel head may be expected to be twice as strong as a bonnet head of the same material, diameter and wall thickness. With a medium rod and careful welding, a hemispherical orange-peel head should sustain a circumferential stress of 55,000 lbs./in.^{2} while a bonnet head should sustain a corresponding stress of 28,000 lbs./in.^{2} A factor of safety of at least 2 should be used to forestall possible variations in head shape, material and welding. GN(6)

Chemical Composition and Mechanical Properties of Centrifugal Castings. J. E. Hurst. *Metallurgia*, Vol. 2, May 1930, pages 13–16; June 1930, pages 53–56.

A review of segregation and mechanical properties of centrifugally cast pipe and piston rings. Gives methods of testing these materials as well as results of tests. Contains 7 references. JLG(6)

The Influence of Aging and Blue Brittleness on the Continuous Impact Test. (Einfluss des Alterns und Blaubruchs auf die Dauerschlagprobe.) A. Kühle. *Mitteilungen Forschungs-Institut Vereiningte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 1, No. 4 (1929) pages 83–102, 22 references.

The results of this investigation showed that the impact number increased by 45% in a test sample which was aged. The metallographic examinations of the impact tests exhibited recrystallization. In a sample of steel which was subjected to a preliminary heat treatment at 200–300° C. an unusual increase in brittleness occurred. The notch tests gave a value of under 5 mkg./cm.^{2} in a test piece which was annealed at 100–500° C. By aging the impact test number increased. GTM(6)

Hardness Testing of Chill Castings. (Die Prüfung der Härte von Schalenhartguss.) O. Küne. *Kruppsche Monatshefte*, Vol. 10, Dec. 1929, pages 200–203.

Gives features of Brinell and scleroscope hardness-testing methods. It is shown, on the basis of various measurements, that the last-mentioned method gives widely deviating results in the case of hardness testing of hard chill castings. On the other hand, test results check in the case of hardened steel. Gives method for calibration of scleroscope. (6)

Problems in Technical Cohesion. (Fragen der Technischen Kohäsion.) W. Kuntze. *Zeitschrift für Metallkunde*, Vol. 22, Aug. 1930, pages 264–268.

A discussion of the relative effects of shear and separation-resistance upon process of failure in tension and failure of fatigue. The abnormally low values of strength (as compared to theoretical values) are explained by crystalline imperfections. EF(6)

Calculation of Vibration Strength from Tensile Strength and Elastic Property. (Berechnung der Schwingungsfestigkeit aus Zugfestigkeit und Trennfestigkeit.) W. Kuntze. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. 22, 1930, pages 231–234.

In trying to explain the conception of vibration strength by means of elastic strength in order to find a plastic range of stress free of fatigue, a formula was developed for the vibration strength which was found to be correct by practical tests. The latter were made with different kinds of materials. 7 bibliographical references. Ha(6)

Fatigue Tests with Construction Materials. (Dauerversuche an Werkstoffen.) P. Ludwik. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 21, 1929, pages 1801–1810.

This paper is a summary of very exhaustive tests on the flow of solid bodies, continuous and variable loads, internal stresses, structure, fatigue fracture, short-cuts of fatigue tests, relation between vibration resistance and other properties, influence of nature of surface, notches and heat treatment and impact fatigue test. The results are illustrated by many micrographs and diagrams. 49 bibliographical references are cited. Ha(6)

Determination of the Quality of Rails. (Evaluation de la qualite des rails de chemins de fer.) A. N. Mitinsky. *Revue de Metallurgie*, Vol. 27, July 1930, pages 370–380.

Summation of the results obtained from practical testing of rails begun in 1899. Segregations in rails are harmful only at very low temperatures. According to the experience of Russian railroads brittleness is dangerous, but it cannot be determined with an impact test as far as the performance of rails is concerned. Fissures are absolutely inadmissible. Brittleness can be caused by many factors, largely by too hot finishing temperature and by the presence of manganese. The crushing of the head is determined by the elastic limit of steel. Composition is of but little importance. Some rails with 0.12% C carried more than 50 million tons, some with 0.67% C failed under 10 million. In the light of performance the steels can be separated on those having the yield point and elastic either close or widely separated. The yield point cannot be used for the determination of the elastic limit. Static resistance depends on the yield point, the resistance to repeated strains as elastic limit. Rails are tested in Russia on the basis of their elastic limit. Testing procedure used is described. The acceptance is determined by the impact test on the whole rail and elastic minimum figures. For the first grade 25 kgs./mm.^{2} (35,500 lbs./in.^{2}) and for the second 20 kgs./mm.^{2} (28,400 lbs./in.^{2}) are accepted. JDG(6)

Mechanical Properties of Nickel and Nickel Chromium Steel. (Proprietes mecaniques des Aciers aux Nickel et au Nickel-Chrome.) J. S. Negru. *Aciers Speciaux, Métaux et Alliages*, Vol. 5, No. 57, May 1930, pages 201–216.

A general description and comparison of the S.A.E. Ni and Ni-Cr steels in the light of the European user. Heat treatments and the resulting mechanical properties are given. GTM(6)

Testing of Permanent Magnet Steel. (Die Prüfung von Dauermagnetstahl.) W. Oertel. *Stahl und Eisen*, Vol. 49, Oct. 3, 1929, pages 1449–1454.

Brief description of commonly used magnet-testing equipment and their defects. Details of operation and calibration of new apparatus developed by Bosch and the results obtained are given. Comparative tests with different apparatus on the same magnet-steel specimens are recorded. (6)

The Magnetometric Determination of the Curie Points. Albert Regner (Technical University, Praha). *Iron & Steel Institute, Advance Copy* No. 6, Sept. 1930, 22 pages.

A low frequency magnetometer and 2 high frequency magnetometers suitable for detecting transformation points in steel are fully described. These instruments gave clear indications of the A_2 point and cementite changes both at 60° C. and 210° C. Irregularities were observed at the temperature of the pearlitic change. Contains 6 references. JLG(6)

Magnetic Properties of Technically Important Alloys. (Magnetische Eigenschaften technische wichtiger Legierungen.) A. Schulze. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Nov. 3, 1929, page 1715.

A condensed review on some iron-nickel and iron-cobalt alloys abstracted from the original articles, the bibliographical references are given. Ha(6)

Brinell, Rockwell and Scleroscope Hardness of Non-Ferrous Metals. (Brinell, Rockwell und Skleroskophärte bei Nichteisenmetallen.) O. Schwarz. *Zeitschrift für Metallkunde*, Vol. 22, June 1930, pages 196–202, 8 references.

The usefulness of hardness determinations as a cheap and valuable method for testing the quality and uniformity of metals and alloys in plant control is pointed out. After discussing the principles involved in the 3 hardness testing machines, the author reports on his experiments with annealed Cu, Cu cold rolled to 5, 10, 20, 40, 60 and 80% reduction in thickness, on brass with 85% Zn annealed and cold rolled to the same reductions in thickness, on brass with 60% Zn and Al with the same treatment, on Scleron age hardened and cold-rolled to 10 and 20% reduction in thickness, on duralumin annealed and cold-rolled to 5 and 10% reduction in thickness. The results are graphically presented in curves in which Brinell numbers are plotted against Rockwell hardness values and equations are given expressing the relationship between both hardness numbers. In some diagrams Brinell hardness numbers are plotted against scleroscopic hardness and the latter against elastic limit. The values graphically presented approach in most cases common curves. It was observed that cold-drawn material shows a non-uniform distribution of hardness the surface being harder than the core. EF(6)

The Statistical Element in Mechanics of Materials. F. B. Seely. *Mechanical Engineering*, Vol. 52, Sept. 1930, pages 839–844.

The article stresses the importance of recognizing the statistical element in the picture of the internal structure of material and stress distribution. The conception of ideal material and of regularity of stress distribution has been too common in the past. GN(6)

The Determination of Elastic Limit and Yield Point of Spring Steel Wire by Means of the Twist Test. (Die Bestimmung der Elastizitätsgrenze und der Fliessgrenze von Federstahldrähten durch den Verwindungsversuch.) E. Siebel & A. Pomp. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 12, No. 7, 1930, Report 149, pages 85–91; *Stahl und Eisen*, Vol. 50, Aug. 21, 1930, pages 1206–1207.

In order to obtain reliable results in testing wire by means of the twist test, the author designed a new apparatus which is able to determine exactly the number of twists for a distinct test length. The new testing method was used to determine the yield curve of patented wires for tension and compression springs. The "twist characteristics," as resulting from the data obtained with the apparatus, give the values of elastic limit and yield point. Since this new method requires too much time for daily routine testing, it is sufficient to determine only that in a certain total twisting the permanent twisting does not exceed a maximum standard value. These standard values have been determined for a group of spring steels. GN(6)

The Testing of Thin Sheets by Means of the Deep-Drawing-Widening Test. (Die Prüfung von Feinblechen durch den Tiefzieh-Weitungsversuch.) E. Siebel & A. Pomp. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 12, No. 9, 1930, Report 151, pages 115–125; *Stahl und Eisen*, Vol. 50, Aug. 21, 1930, page 1207.

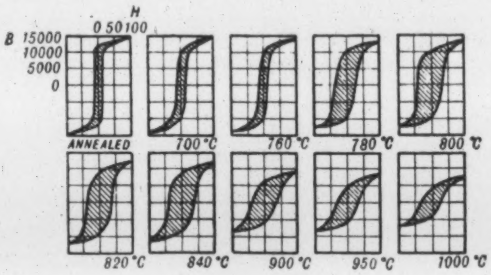
Whereas a former publication on a new deep-draw test (E. Siebel & A. Pomp, *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 11, No. 18, 1929, pages 287–291, Report 136; *Metals & Alloys*, Vol. 1, May 1930, page 524) referred to the development and the theoretical principles of the new test method, this publication gives the results of actual tests on steel and non-ferrous metal sheets. Tensile tests and microcsopic examinations were also carried on for comparison. The results are that the deep-draw-widening test is an excellent means of comparing the qualities of various sheet brands. This test method gives especially valuable information on the structure of the materials tested. The deep-draw-widening test will determine in many cases, where other test methods fail, the suitability of sheets for deep drawing purposes. GN(6)

Modulus of Elasticity of Aluminum Alloys. R. L. Templin & D. A. Paul (Aluminum Co. of America). *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 366 (1930) 9 pages.

The modulus of elasticity of aluminum is 10,000,000 lb./in.^{2} The addition of iron, silicon, copper, nickel or manganese to the aluminum increases this modulus. The modulus is increased as much as 20 or 30% by the presence of considerable amounts of alloying elements. The addition of silicon to aluminum increases this modulus without increasing the density. A large amount of magnesium decreases the modulus of elasticity. JLG(6)

Magnetic Hardness Test for Ball Races. Harald Sjovall (SKF Laboratories, Gothenburg). *Metallurgist*, Aug. 1930, pages 121–122.

The variation in the magnetic properties of ordinary ball-bearing steel of different degrees of hardness is utilized for a quick shop method for determining the hardness of ball bearing races. Fig. 1 gives the hysteresis curves for ball-bearing chromium steel annealed, quenched in water as indicated and then, as usual, tempered to 150° C. The principle of the testing apparatus is shown in Fig. 2. The bearing race to be tested is conveniently placed against a V-shaped stop and is thus located in an alternating magnetic field from a large air coil. The race is small compared with the magnetizing coil, and cannot to any great extent increase the total magnetic flux, but it produces a distortion of the field, such distortion being measured by means of three series-connected secondary coils. Two of these coils are fixed, counteracting each other; the third can be rotated, and is so adjusted for a standard test piece that the system is practically compensated. The resultant voltage induced in the secondary coils is measured by means of an alternating-current galvanometer of dynamometer type with separate excitation, obtained by replacing the permanent magnet in an ordinary moving coil voltmeter with a sheet steel core with winding. This winding is fed with alternating current with a phase displacement so chosen—in relation to that of the main magnetizing coil—that the greatest possible difference in deflection is obtained between a soft and a hard race. For practical purposes this has been achieved in such a way that with a three-phase alternating-current power supply of 25 or 50 cycles per second the main coil has been placed in circuit between two of the phases, and the galvanometer excitation between the third phase and the neutral. The galvanometer is short-circuited and is thus protected so long as there is no race in the apparatus. When the apparatus is to be used, a race of standard hardness is placed against the stop, and the knob is turned until the galvanometer indicates zero. When other races of the same dimensions are subsequently placed in the apparatus the galvanometer pointer deflects towards the "hard" or the "soft" side, thus showing how the races differ from the standard. It is not necessary for the races to be ground or to have clean surfaces. Neither soft spots nor cracks can be detected. Its great value lies in ensuring uniformity of product. Modifications of the apparatus are being studied to take care of various other details. VVK(6)



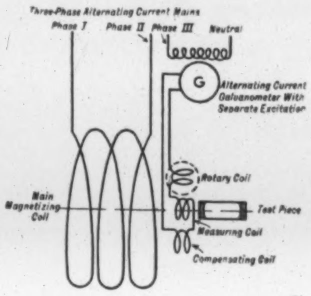


Fig. 1. Above
Fig. 2. At Right

Tension and Compression. *Metallurgist*, Oct. 1929, pages 146–147.

Experience shows that in many ways different mechanical properties of engineering metals are closely linked together. Close correlation exists between tensile strength and Brinell hardness, at all events in steel, while fatigue range also seems to be closely related to ultimate tensile strength. A closer study of the relation between tensile and compression properties of the more important structural materials is essential. (6)

The Work of Rupture in Relation to Fatigue. *Metallurgist*, Aug. 1929, pages 124–125.

A review of work by K. Ljungberg, the main feature of which is the discovery that work per unit volume required to fracture the specimen at any particular section is constant, irrespective of whether work is applied in single stage or a number of stages. (6)

ELECTRO-CHEMISTRY (7)

Direct Electrolytic Production of Beryllium Alloys. (Direkte elektrolytische Gewinnung von Berylliumlegierungen.) K. Illig & H. Fischer. *Wissenschaftliche Veröffentlichungen des Siemens- Konzern*, Vol. 8, No. 1 (1929), pages 88–93.

Alloys with 0.1–40% Al in Be may be obtained by addition of the requisite quantity of cryolite to the Be bath during the Siemens & Halske electrolytic process. Cu alloys with a low Be content may be prepared by using molten Cu as the cathode in the following process, and Be alloys with a small Cu content by adding Cu fluoride to the electrolyte. Ni and Cu alloys can also be obtained by adding Cu or Ni to the bath so that it sinks to the bottom and behaves as the anode, being dissolved by the liberated F and deposited on the cathode with the Be. 3 references. (7)

Electrolytic Production of Cadmium Yellow. Colin G. Fink & William M. Grosvenor, Jr. *Preprint* 58–22, *American Electrochemical Society*, Sept. 25–27, 1930, pages 271–277; *Chemical Trade Journal*, Vol. 87, Oct. 3, 1930, pages 323–324.

The advent of electrolytical cadmium as a by-product of electrolytic zinc has aroused renewed interest in the metal and its products. Cadmium yellow is one of the best yellow pigments available. It is brilliant and very permanent. Present methods of manufacturing the color are not satisfactory. An electrolytic method was developed which suggests commercial possibilities. Ferrous sulphide serves as the source of sulphur. The electrolyte is a weakly acid solution of an alkali sulphide. A two-compartment cell is used, the voltage ranging between 0.2 and 0.5. A finely divided iron powder is produced as a by-product. (7)

The Theory of Electrodes. E. Newbery. *Preprint* 58–3, *American Electrochemical Society*, Sept. 25–27, 1930, pages 19–42.

The whole theory of electrode behavior has been reviewed, including single potential determinations, overvoltage, transfer resistance, valve action and passivity. Normal electrode potentials are periodic functions of the atomic numbers of the elements, and those of the inert gases are probably zero. When a gas is liberated at an electrode, transfer resistance always appears, and is due to the purely ohmic resistance of a film of gas under high pressure, covering the electrode. The properties of transfer resistance are described, and an explanation given of the function of platinizing electrodes for conductivity determinations. Under the same conditions, overvoltage usually, but not always, appears. This is due to the formation of compounds of the liberated gas with the material of the electrode, under the influence of the very high pressures present. The properties of overvoltage are briefly described. Valve action occurs when the anodic compound is insoluble in the electrolyte and an electrical insulator, forming a covering film which is permeable to hydrogen ions but impermeable to the anions present. Passivity occurs when the anodic compound is insoluble in the electrolyte, and is also an electrical conductor. (7)

Gas Electrodes. Albert Krueger & Louis Kahlenberg. *Preprint* 58–26, *American Electrochemical Society*, Sept. 25–27, 1930, pages 341–383.

The effects of oxygen, hydrogen, nitrogen, helium and argon upon the potentials of the common metals and carbon were studied in KCl, KOH and HCl solutions. The potentials observed were compared with one another. A striking effect noted is that the potentials of the following metals are only slightly affected by any of the gases, no matter which of the 3 electrolytes was used: arsenic, natural graphite, cocoanut charcoal, cadmium, mercury, molybdenum, lead, silicon, tin, tantalum, tellurium, tungsten and zinc. All the experimental data collected demonstrate clearly that there is no such thing as a gas electrode and that the so-called gas electrodes are really gas-metal electrodes. The presence of a gas affects the potential of any metal. This effect is highly specific, and varies with the nature of the gas, of the metal and of the electrolyte. The potential effects observed in the individual cases have been discussed and arranged in tabular form. The potential effects noted apparently have nothing to do with valence, or the usual position of the elements in the periodic systems; nor is it possible to arrange such potentials in hard and fast series of any kind. On account of their highly specific nature, and on account of the unusual behavior of the various electrodes studied, these phenomena deserved further detailed study. Especially is this true of the effects produced by gases as argon and helium, which are supposed to be chemically inert. Argon and helium have been found to produce fully as characteristic potential effects as hydrogen, oxygen and nitrogen. If argon and helium are really inert gases, this would mean that the potentials are not due to chemical affinity. If it be insisted that the potentials are produced by chemical affinity and are a function of the latter, it would follow that argon and helium are not inert gases, as has hitherto been held. (7)

The High Voltage Anodic Layer on Aluminum. J. E. Lilienfeld, L. W. Appleton & W. M. Smith. *Preprint* 58–24, *American Electrochemical Society*, Sept. 25–27, 1930, pages 285–331.

This paper consists of an experimental chemical and another experimental physical part. The results are surveyed and the conclusions drawn in a third chapter. The chemical experiments were (aside from the preparation of the anodes for the physical tests) concerned with the question, whether or not the oxygen is deposited upon the anode during formation of the layer according to Faraday's law of equivalents, assuming in accordance with many of the former investigators, that the layer consists of an oxide and hydroxide of aluminum. The work covered a wide range of concentrations, temperatures and current densities. Not one of the observed phenomena was critically sensitive to variations of these conditions. While this is so, the results show, on the other hand, that the total amount of oxygen released at the anode is of an entirely different order of magnitude and much larger than the amount of oxygen included in the layer, as calculated on the basis of the general knowledge about the order of magnitude of the thickness of the layer. As a result of the physical investigation it is concluded that the behavior of the layer corresponds to that of a dielectric containing a large number of polar molecules. The electric field in the layer, and, therefore, the potential applied to it, determines its properties. The current, on the other hand, using in its initial, or in its recurring formation, is a secondary factor only, and does not involve any basically simple relations. Thus the law of chemical equivalents cannot be broadly applied in determining either the capacity or the resistance of the layer on the basis of its formation process. Although the present study deals with only a specific example of a broadly general type, the experimental methods developed and recorded and the hypotheses introduced should prove applicable to the investigation of other similar cases of conductivity; and applicable to a systematic presentation of the subjects of highly asymmetric conductivity, and the behavior of dielectrics containing polar molecules in extremely intense electric field. (7)

The Electrode Properties of Stainless Steel. Edgar Newbery. *Preprint* 58–25, *American Electrochemical Society*, Sept. 25–27, 1930, pages 335–340.

The electrode properties of a highly pure commercial iron, a sample of stainless steel, and of electrothermally prepared chromium were compared. When no current passes, an electrode of stainless steel behaves like metallic chromium. When made cathode, stainless steel behaves like pure iron and shows no resemblance to chromium. When made anode, stainless steel behaves like chromium at low current densities and like iron at high current densities, the change of properties occurring quite suddenly. A tentative explanation of the above phenomena is suggested. Stainless steel or stainless iron appears to be specially suitable as an electrode for the controlled electrolytic reduction or oxidation of certain substances. (7)

Electroplating

The Deposition of Nickel-Cobalt Alloys. Colin G. Fink & Kihough H. Lah. *Preprint* 58–18, *American Electrochemical Society*, Sept. 25–27, 1930, pages 241–249.

The co-deposition of cobalt and nickel from the sulphate-chloride bath was investigated. A silver-white deposit can be obtained within the wide range of 55–75% Ni and 45–25% Co. Cobalt dissolves anodically more readily than nickel in the sulphate-chloride bath, and also deposits cathodically more readily than nickel. Increasing the total metal concentration of the bath increases the cobalt content of the plate. Increasing the temperature of the bath, decreasing the acidity, or increasing the cathode current density likewise increases the cobalt content of the plate. The white alloy plate is more than 3 times as hard as nickel, and decidedly more resistant to corrosion than nickel. (7a)

The Preparation of Pure Electrolytic Nickel. Part II. The Final Elimination of Copper and the Removal of Cobalt and Iron. Colin G. Fink & F. A. Rohrman. *Preprint* 58–8, *American Electrochemical Society*, Sept. 25–27, 1930, pages 83–100.

The electrochemical methods for removing traces of copper and cobalt from nickel sulphate solutions were further investigated. When 2 or more metals are present in solution, it is difficult to predict which one will preferably deposit on the cathode, owing to many conflicting factors. By carefully selecting and controlling such factors as temperature, current density, hydrogen ion concentration, and cathode polarization film thickness, one metal may be deposited in preference to others even when such metal is present in solution in relatively small concentrations. The cathode polarization film thickness can easily be varied by employing a rotating cathode, operated at speeds of from 1000 to 6000 r. p. m. or a rapidly circulated cathode. The concentration polarization effect at the cathode can be almost entirely eliminated by means of the high-speed rotating cathode or by a rapidly circulated catholyte. Copper was removed almost quantitatively from solutions containing as little as 0.001% copper. Copper was readily recovered from tail waters containing 0.01% copper and 0.02% iron, which latter, under ordinary conditions, prevents deposition of copper. From a solution containing both nickel and cobalt, in the ratio 100:1, a nickel-cobalt alloy deposit was obtained, containing over 50% cobalt. The commercial possibilities of a high-speed rotating cathode or of a vigorously circulated catholyte are discussed, and commercial adaption of the method briefly outlined. The nickel metal obtained is free from cobalt and iron, and contains only a trace of copper, less than can be determined chemically. A simple laboratory scheme of continuously circulating the electrolyte in a 6-liter cell is described and illustrated. (7a)

The Electrodeposition of Lead-Thallium Alloys. Colin G. Fink & Clarence K. Conard, Jr. *Preprint* 58–23, *American Electrochemical Society*, Sept. 25–27, 1930, pages 279–284.

Alloys of lead-thallium containing from 20 to 65% Tl are among the most insoluble alloys known. The co-deposition of the 2 metals was investigated, and it was found that good, smooth, adherent deposits of an alloy containing approximately 70% lead were obtained from a perchlorate bath of the 2 metals (30 g./l. Tl; 5 g. /l. Pb) at a current density of about 5 amp./ft.^{2} (0.54 amp./dm.^{2}) and 25° C. (7a)

Contamination from the Anode in Gold Electrolysis. (Die anodischen Verunreinigungen in der Goldelektrolyse.) Ralph W. Harbison. *Deutsche Goldschmiede-Zeitung*, Vol. 33, March 22, 1930, pages 139–140.

General discussion of the electrolytic refining of gold. The gold anodes often contain as impurities besides metals of the platinum group copper, bismuth, lead and small amounts of selenium, tellurium, arsenic and antimony. Lead may cause considerable trouble on account of the anode becoming passive. High silver content also causes passivity and increased acidity of the bath. Copper is especially harmful when anodes of low silver content are used. When the platinum content of the electrolyte is twice the gold content platinum is deposited on the cathode. Palladium is soluble in a warm bath up to about 0.5%. Most of the iridium, rhodium and osmiridium go to the anode sludge. Traces of bismuth, selenium, tellurium, arsenic and antimony contaminate the cathode and make it brittle. They should be removed by fire refining. With an anode containing 90% Au, 8% Ag and 2% Cu the sludge has about one tenth the weight of the cathode and contains from 5–15% Au. Besides ordinary insoluble impurities and oxidation products, the sludge contains small amounts of undissolved anode. In general it is better to use a cold solution with a high current density than a warm solution with a low current density. JLG(7a)

Conductivity and Density of Chromic Acid Solutions. H. R. Moore & W. Blum. *Bureau of Standards Journal of Research*, Vol. 5, Aug. 1930, pages 255–264.

The conductivity and density of chromic acid solutions were determined for concentrations up to 10 molar (1,000 g./1. of CrO_3). The density is practically a linear function of concentration. The conductivity increases to a maximum at about 5 molar and then decreases. (7a)

Calcium Chloride Testing of Electroplated Deposits. H. C. Mougey. *Preprint* 58–21, *American Electrochemical Society*, Sept. 25–27, 1930, pages 265–270.

Calcium chloride has become a common dust and puddle constituent on many of the automobile highways. It is much more corrosive to plated parts than sodium chloride. However, no quantitative relation between the salt spray test and the calcium chloride spray test could be established. Calcium chloride will attack chrome-plate more easily than sodium chloride, due possibly to the interaction of the carbonic acid of the air, with the calcium chloride, forming free hydrochloric acid. The calcium chloride spray test is recommended to the chromium plating industry, as an aid in developing a more resistant chrome plate. (7a)

The Computation of Throwing Efficiency. L. C. Pan. *Preprint* 58–20, *American Electrochemical Society*, Sept. 25–27, 1930, pages 255–263.

Haring and Blum's definition of throwing power and Heatley's modification of same were reviewed. "Throwing efficiency" was proposed to designate Heatley's definition. Throwing efficiency is a value which indicates how nearly the throwing power is approaching perfection. Cadmium, nickel and acid zinc baths were used in an experimental study of both the throwing power and throwing efficiency with different primary current distribution ratios. Throwing efficiency gives a more uniform value with change of the primary ratio, but it still varies with the primary ratio. A simpler and more practical method of determining throwing power of electroplating baths is needed. (7*a*)

Wood's Metal as Cathode Material in Electrolysis. (Zur Veröffentlichung von H. A. J. Pieters: "Woodsches Metall als kathodenmaterial bei Elektrolysen.") H. Paweck. *Zeitschrift für analytische Chemie*, Vol. 79, No. 3–4 (1929) pages 113–114.

Under the above title, H. A. J. Pieters has published a paper (*Chemische Weekblad*, Vol. 25, Dec. 22, 1928, pages 706–707) in which he was modified the earlier directions of Paweck and Wiener. Paweck now claims that Pieters would have had less difficulty if he had followed the original directions more closely. (7a)

Notes on the New Electroanalytical Principles of Using Wood's Alloy as Cathode. (Beiträge zu dem neuen elektroanalytischen Arbeitsprinzip mit Woodscher Legierung als Kathode.) H. Paweck & W. Stricks. *Zeitschrift für analytische Chemie*, Vol. 79, No. 3–4 (1929) pages 115–134.

Detailed directions are given for determining Sn, Ag, Fe, Ni, Co and Tl with the molten Woods' alloy as cathode. The results appear to be very accurate. (7a)

The Deposition of Nickel at a Low pH. W. M. Phillips. *Preprint* 58–16, *American Electrochemical Society*, Sept. 25–27, 1930, pages 221–228.

The advent of highly corrosion-resistant nickel-chromium steels in thin sheet form has spurred the plating industry on to improve the quality of its work. Deposits of nickel thicker then the usual 0.0002-inch (0.8 micron) are costly when using the standard pH of 5.3 and above. However, with pH below 3.0 much higher current densities are possible and good, heavy deposits obtained. In the low pH bath the nickel content is kept constant by a fairly uniform anode dissolution. No peeling or cracking at the edges is apparent. The bath remains clear. However, with the low pH bath, there is a greater initial tendency toward pitting. Cathode efficiencies are about 75% as compared with 95% with the standard pH. Lower bath temperatures are recommended for the low pH bath. Zinc base die castings are more difficult to plate with the low pH bath. (7a)

Electrodeposition of Iron-Nickel Alloys from Cyanide Solutions. Lawrence E. Stout & Jonas Carol. *Preprint* 58–15, *American Electrochemical Society*, Sept. 25–27, 1930, pages 207–219.

It is shown that an alloy containing nickel and iron may be deposited from solutions containing potassium nickel cyanide, potassium ferro-cyanide, and potassium tartrate. Plates are deposited over wide ranges of temperature and current density. The compositions of the plates are tabulated and plotted in curves to show the variation in composition of deposit with variations in composition of solution, current density and temperature. (7a)

Plating of Aluminum and Its Alloys for Protection. *Brass World*, Vol. 26, July 1930, pages 181–183.

An abstract of a paper by H. C. Cocks (Royal Aircraft Establishment, Farnsworth) and read before the Electroplaters' and Depositors' Technical Society. A comparison of deposits from sulphate and cyanide zinc baths shows that excellent results are obtained with both types of deposits, although protection from the former bath is superior. The sulphate bath gave best results with a pH of about 4.0, and with moving of the work to and fro. A sodium zinc cyanide sodium zincate bath and an ammoniacal zinc cyanide bath were tried with the latter the better. Sea water was sprayed thrice daily on all specimens. After two years all deposits from the sulphate bath failed to show any signs of corrosion. The sulphate containing gum arabic is recommended with a current density of 30 amperes per sq. ft. and a pH of 4. A brief discussion is included. WHB(7a)

Electrometallurgy

Electrolytic Recovery of Lead from Lead Sulfate Waste. Colin G. Fink & Lawrence Greenspan. *Preprint* 58–6, *American Electrochemical Society*, Sept. 25–27, 1930, pages 69–74.

An economical method of recovering lead from lead sulphate, which occurs as a by-product in a number of industries, constitutes a problem which has not as yet been satisfactorily solved. The present investigation was therefore undertaken to discover a practicable method for utilizing this waste material. Pyrometallurgical and chemical methods suggested in the past are briefly reviewed, and found to be impracticable. A new electrochemical method is proposed and developed. The electrolyte contains from 50 to 55 g./l. $PbSO_4$ and 200 to 240 g./l. NaOH; current density 1.6 amp./dm.^{2}; temperature of electrolyte 65 to 70° C.; lead-silver anodes; current efficiency 95–98%. The cell is divided into 2 compartments by an alundum diaphragm. Two valuable by-products are obtained, red lead and Glauber salt. The cathode deposit of metallic lead produced in the presence of glue as an addition agent is crystalline and well adherent. (7b)

Production of Electrolytic Deposits of Beryllium by High Temperature Electrolysis. (Herstellung von galvanischen Berylliumüberzügen auf dem Wege der Schmelzflusselektrolyse.) Hellmut Fischer. *Wissenschaftliche Veröffentlichungen des Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 83–87.

By electrolysis of a molten bath consisting of equal parts of Be oxyfluoride and NaF, with cathodes of Al, Cu, Ni or Fe, the cathode may be coated with a smooth bright and hard deposit of metallic Be. By subsequent annealing a layer of alloy may be obtained owing to diffusion, and in the case of the 3 last-named metals it can be hardened by suitable heat-treatment. Cu is plated at 750°, Al at 580° and Ni and Fe at 900°. 2 references. (7b)

Influence of Bath Composition and Bath Temperature on the Stock-Goldschmidt-Siemens & Halske Method for the Production of Beryllium. (Studien über den Einfluss von Badzusammensetzung and Badtemperatur auf das Stock-Goldschmidt-Siemens & Halske-Verfahren zur Gewinnung von Beryllium.) H. Fischer. *Wissenschaftliche Veröffentlichungen des Siemens-Konzern*, Vol. 8, No 1 (1929) pages 59–73.

Be oxyfluoride is not a conductor of electricity, but becomes a conductor on the addition of BaF_2, the current yield rising linearly to a maximum of 80% with 45% of BaF_2 in the mixture and falling again with more than 50% of the Ba salt. The current yield is reduced rapidly by the addition of NaF to the bath, alkalies and alkali chlorides increase the loss by volatilization, and Al, Si and Fe compounds contaminate the deposited metal. The electrolysis must be carried out in an oxidizing atmosphere to prevent C from the anode entering the metal. The best results are obtained at 1400° with a current density of 100–400 amp./cm.^{2} of cathode area. 18 references. (7b)

Electrolytic Production of Beryllium. (Gewinnung von Beryllium durch Elektrolyse.) K. Illig, M. Hosenfeld & H. Fischer. *Wissenschaftliche Veröffentlichungen des Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 42–58.

After a historical survey of the work of earlier investigators on the preparation of Be by electrolysis of fused salts an account is given of the Stock-Goldschmidt process and its more recent modifications. The original method gave relatively poor yields of metal because of the high volatility of the salts used at the working temperature of 1350°. Much better results are now obtained by the use of a bath consisting of a mixture of BaF_2 and Be oxyfluoride. The vapors evolved are drawn by suction through water, thence through a wash tower packed with Raschig rings. The solution in the tower after operating the process contains Be oxyfluoride while Ba fluoberyllate remains in suspension; both salts are readily recoverable for further use. The electrolysis is carried out at 1400° in a graphite crucible which serves as anode, a water-cooled iron tube being used as cathode; fresh charges of Be oxyfluoride and BaF_2 are added from time to time to replenish the loss by volatilization and electrolysis, so that the furnace can be operated for 24 hours at a time. The metal is obtained in the form of rough rods containing as impurities 0.31% Fe, 0.17% Al and 0.04% C. The current yield is 75–80% of the theoretical and the recovery of metal about 90%. The metal may be freed from inclusions of salts by fusion under a flux consisting of a mixture of alkali and alkaline earth chlorides. Attempts to prepare Be by electrolysis of the oxide dissolved in fused cryolite, borax, alkali hydroxides or cyanides failed. 20 references. (7b)

METALLIC COATINGS OTHER THAN ELECTROPLATING (8)

The Destructive Action of Molten Zinc at and above Zincing (Galvanizing) Temperatures upon Metals and Alloys. Wallace G. Imhoff. *American Metal Market*, Vol. 35, 1928, 2nd Section, pages 10–13; Vol. 36, Feb. 19, 1929, pages 5, 13; Oct. 8, 1929, pages 4, 5; Dec. 6, 1929; Vol. 37, Feb. 11, 1930, page 6; June 3, 1930, page 5; July 22, 1930, page 10; July 23, 1930, page 10.

Zinc is considered from the standpoints of its properties, its abundance, and as a metal for protective coatings. Data on physical and chemical properties of a number of metals and alloys particularly zinc and its alloys are given. It has been proved that under ordinary galvanizing conditions practically no zinc is lost by evaporation, and that metal temperatures have important bearing on kettle life, dross production, quality of zinc coating, purity of metal bath and the production of zinc skimmings. Next in importance to metal temperature is the purity of the base metal and the kind of base attack. Two distinct features regarding the attack of molten zinc are: (1) the steel base must be sound to resist attack as oxidation and segregation are causes of failure, and (2) the corrosion of the pot is mild up to 900° F., but violent above that temperature. Weight losses are shown upon immersion in molten zinc for long periods of time. The rate of solution increases directly in production to the amount of impurities and it increases with the amount of oxygen. Fire-box steel and boiler steel offer the best resistance. A graph is shown of various zinc-iron alloys. Temperature is regarded as the most important factor in galvanizing pot destruction. The pan should be kept at fairly even temperatures, and it is necessary to avoid complete cooling and reheating, lest crusts of hot zinc should peel off and impair the iron locally. An increase in silicon increases the solubility of iron; the lack of homogeneity in the structure of the iron acts similarly. Changes in carbon and manganese have little effect. Several tables, photographs and photomicrographs are shown. Zinc at high temperatures attacks cast iron and malleable iron to a very marked degree, if left any great length of time in the galvanizing bath. A study is made of the effect of molten zinc on two special heats of steels. A great difference was found in the resistance to molten zinc, depending on whether the chromium is in the steel base or in the form of chromium metal as plate. Specifications for making the steels are given. Analysis was: carbon under 0.20%, preferably 0.10–0.15%; manganese, 0.50–0.75%; phosphorus, not over 0.035%; sulphur, not over 0.040%; nickel, 5.0–8.0%; chromium, 0.70-1.0%; silicon, 0.20–30%. Reasons for these specifications are given. Results of the subjection of test pieces to immersion in molten zinc are shown and illustrate clearly that the steel with the higher chromium and nickel content is much more soluble (almost three times) in molten zinc. Chromium and nickel finely disseminated through the steel or chemically combined in the steel aids the metal to resist the corrosive action at galvanizing temperatures. Results indicate that no beneficial results are obtained by putting chromium and nickel in steel that is to be used for galvanizing pots. Properties of nickel and chromium are compared. Twelve hours' exposure of strips of monel metal and of pure nickel in a molten zinc bath at 860° F. shows little corrosion in either case, though a slight alloy formation had started on the monel metal. Submersion for $148^1/_2$ hours showed corrosion of each strip. Nickel shows the least corrosion of all the metals tested. Features noted are that nickel seems to dissolve into the zinc but no nickel-zinc alloy-like dross is formed simultaneously. Tests on Nichrome and Pyrasteel (nickel 25%, chromium 14% and silicon $2^1/_2$-3%) were not conclusive. Wrought metals show greater resistance to the corrosive effect of molten zinc than do cast metals. Metallic nickel and metallic chromium seem to resist it more than iron and steel. Copper and its alloys are readily attacked by molten zinc at galvanizing temperatures. Everdur (copper 94.76%, silicon 4.13%, manganese 0.74%, phosphorus 0.06% and iron 0.04%) was tested to note its resistance to the molten metal. It was rapidly attacked and dissolved, and the zinc coating does not adhere to the alloy. Both Duriron and Ferralt corrode extremely rapidly. Pure metals resist corrosion by molten zinc better than do their alloys. No metal or alloy has yet been found that will resist this alloying action indefinitely under practical galvanizing conditions. WHB(8)

Investigation on the Decrease of the Zinc Deposit in Hot Galvanizing as Caused by Additional Metals. (Untersuchung über die Verminderung der Zinkannahme beim Feuerverzinken durch Zusatzmetalle.) W. Prungel. *Stahl und Eisen*, Vol. 50, Aug. 14, 1930, page 1173.

The thesis by W. Römer (Technical Hochschule Karlsruhe 1929) on the mentioned subject is reviewed. The reactions which have their bearing on the corrosion of metals and the rusting of iron are critically discussed and the conditions are studied under which a decrease, of the amount of deposited zinc, is possible for obtaining the best properties of the zinc coating. Only iron sheets were tested. Concentration of the pickling bath, time of pickling, temperature and composition of the zinc bath and dipping time are of importance. The best composition of the zinc bath is 97.4% Zn, 0.6% Al and 1.5% Cd. The best bath temperature is 430° C. GN(8)

Metal Coating Combustible Substances. (Metallisierte brennbare Stoffe.) M. U. Schoop. *Chemische Fabrik*, Vol. 2, Dec. 25, 1929, page 537.

A new pistol especially adapted to spraying paper is described.. (8)

INDUSTRIAL USES & APPLICATIONS (9)

High-Speed Steel Hacksaws. J. H. Barber. *Metallurgia*, Vol. 2, May 1930, page 25.

High-speed steel hacksaw blades give remarkable service as compared with the more generally used blade containing from 1 to 2% tungsten. To obtain the full advantage of these blades they should be used in faster machines. Curves are given showing a high-speed steel hacksaw blade having a life of 168 cuts as compared with 16 cuts with the usual type blade. JLG(9)

Zinc in Brass. William A. Willis. *Metal Industry* (London), Vol. 37, No. 8, Aug. 22, 1930, pages 173–174.

Discusses the wide spread uses of brass, and gives the composition of a number of brasses. VSP(9)

Standard Specifications for Structural Silicon Steel. *American Society for Testing Materials, Standards-Supplement* (1929) pages 22–26.

These specifications cover: process, discard, chemical composition ladle analyses, check analyses, tension tests, modifications in elongation, modifications in reduction of area, bend tests, test specimens, number of tests, permissible variations, finish, marking, inspection, rejection, reheating. (9)

Aluminum Alloys. *Metallurgist*, Dec. 1929, pages 178–179.

While the motor car might profit very much by the saving of weight, there are other branches of engineering where the possibilities of light alloys do not appear to have been fully appreciated. This applies most markedly to all forms of moving objects which have to be started and stopped many times, whether these be parts of fast-moving machinery or vehicles of subway or suburban railway. (9)

The Use of Nickel Alloys in Aircraft Engine Design. *Nickel Bulletin*, Vol. 3, June 1930, pages 179–186.

Engine parts illustrated and discussed. Table gives chemical analyses and physical properties. (9)

Standard Specifications for Structural Nickel Steel. *American Society for Testing Materials, Standards-Supplement* (1929) pages 16–21.

The given specifications cover: process, discard, chemical composition, ladle analyses, check analyses, tension tests, modification in elongation, character of fracture, bend tests, drift tests, test specimens, number of tests, permissible variations, marking, inspection, rejection, reheating, tests of eye-bars. (9)

The Return of Pewter. *Brass World*, Vol. 26, Aug. 1930, pages 215–216.

A reprint of an article in *Dutch Boy Quarterly* Vol. 8, No. 2, 1930. Pewter may be obtained in sheets, circles, or in special shapes and is mainly employed in the manufacture of goblets, ash trays, trophy cups, pails, salt cellars, and other small objects that are handled a good deal. WHB(9)

Aluminum Frame Reduces Railway Motor Weight. *Electric Railway Journal*, Vol. 74, Sept. 1930, page 576.

Making end housings and axle caps of aluminum would effect savings of 600-1000 lbs. on a 200-hp. single-phase motor of the type used by several railroads using electrical power. Plans are under way by the Westinghouse Electric & Manufacturing Co. for the introduction of test equipment of the aluminum-equipped single-phase railway motors, to obtain actual service runs. WHB(9)

Production and Uses of Light-Metals. (Herstellung und Verwendung von Leichtmetallen.) K. Arndt. *Elektrotechnische Zeitschrift*, Vol. 50, Sept. 12, 1929, pages 1332–1334.

The author furnishes statistics of location and production of aluminum and light metals and discusses their uses which have lately extended very greatly. Pure aluminum is used for fermentation tanks, distillery apparatus, electric cables, house utensils, very thin foils; aluminum alloys are extensively used in aeroplane construction and automobiles. Magnesium in the form of electron metal contains 6% Al, 1% Zn and 0.2% Mn. About 2000 tons of this material are used annually in aeroplanes, motor cars, etc. Calcium has proved to be a good substitute for tin in bearing metals. An alloy of lead with 0.6% Ca, 0.6% Na and 0.04% Li is used in bearings of the German State Railways; it has the advantage of a higher melting point than the usual metal. Beryllium is used as an addition to copper, $2^1/_2$% renders it stronger, more elastic and refinable. Sodium metal is used in Silumin, an alloy of aluminum with 12% Si and 0.1% Na which latter gives it a very fine grain which it does not have without Na. There are 3 references. The paper also contains some physical properties of all these metals. Ha(9)

Skyscrapers. *Engineer*, Vol. 150, Aug. 29, 1930, page 226.

From address delivered by E. Pistor at Paris under the auspices of the Technical Bureau for the Utilization of Steel. Traces history of use of steel in skyscrapers and part played by steel in rapid erection of such buildings. Steel framework bears weight of building now while formerly it was borne by walls. LFM(9)

Rail Breakages and Experiments with Heat-Treated Rails. W. C. Cushing (Penna. Railroad). *Iron Age*, Vol. 125, April 24, 1930, page 1224.

Abstract of paper before American Railway Engineering Association. Rails must be made from sounder, cleaner and more uniform metal than is ordinarily found in steel rails. By heat treatment elastic limit will increase 60%, strength and endurance limit 25%, elongation 35% and area reduction 140%. These figures of improvement are not only over standard C steel, but represent corresponding gain over any alloy or special mode of manufacture tried. One third of breakage may be ascribed to poor maintenance of ties and ballast, remainder is due to segregation and heavy stresses. VSP(9)

The Story of Aircraft Tubing. S. L. Gabel & H. C. Knerr. *Aviation*, Vol. 28, March 28, 1930, page 632.

This is the first of a series of 3 articles that present an excellent picture of the history, manufacture and characteristics of tubing and interesting details concerning improvements in the machinery used in its manufacture. With the great savings in weight made possible by use of properly heat-treated alloy-steel tubing, little doubt exists of its present and future use in aircraft construction. (9)

Nickel Finds Greatest Use in Structural Steel. T. W. Gibson. *Engineering & Mining Journal*, Vol. 128, Oct. 5, 1929, page 541.

An abstract from the current volume of *Mineral Industry*. The 4 chief uses of nickel are: (1) as a component of alloys; (2) as a surface coating for other metals; (3) as a chemical or catalytic reagent; and (4) as a pure metal. The uses of nickel, based on an output of 40,000 tons per year, are indicated by Robert C. Stanley. WHB(9)

Monel Metal Condenser Tubes. J. Ireland. *Nickel Bulletin*, Vol. 3, June 1930, pages 187–190; *Mechanical World*, Nov. 22, 1929, page 490.

Review of the application of Monel Metal for condenser tubes. Historical development. Practical results from long time industrial performance. Advantages of mechanical properties and corrosion resistance. (9)

Copper Steel for Dynamo and Transformer Sheets. (Gekupferter Stahl für Dynamo und Transformatorenbleche.) A. Kussmann & B. Scharnow (Physikalisch-Technische Reichsanstalt Berlin). *Stahl und Eisen*, Vol. 50, Aug. 21, 1930, pages 1194–1197.

The influence of copper on the magnetic and electric properties, corrosion resistance, hardness and tensile strength of dynamo sheets and transformer steels with 1.5% Si and 4.0% Si was tested in annealed and unannealed condition. The samples melted in a small high frequency furnace and containing 0.0%, 0.2%, 0.3%, 0.5%, 0.75% and 1.0% Cu were poured in steel molds and forged to cylindrical bars at 1000° C. The hot plasticity was not impaired by the addition of Cu. The mentioned tests were made with these steels. The magnetic properties were examined for other steels with copper contents up to 4%. There is practically no change of the magnetic properties (induction, maximum permeability and coercive force) for copper contents up to 0.7% in comparison with copper free steels. The hysteresis loss, therefore, is also alike. The electric conductivity is practically constant. The corrosion resistance is essentially increased by copper, more for dynamo steel than for transformer steel. The smallest corrosion attack is already reached at a copper content which does not change the magnetic and electric properties. The Rockwell hardness increases with the copper content. The authors finally draw the conclusion that a certain copper content can be allowed in dynamo and transformer steels with high corrosion resistance without impairing its magnetic, electric and physical properties. GN(9)

Alloy Steels in the Railroad Field. C. McKnight. *Advance Paper* No. 26, *American Society of Mechanical Engineers*, Dec. 2–6, 1929, 7 pages; *Railway Mechanical Engineer*, Vol. 104, Jan. 1930, pages 37–40.

The uses of three ranges of steel are given. (1) Carbon steels are used for the vast majority of railroad purposes. (2) Alloy steels are used for special applications. (3) Semi-Alloy steels, which are slightly more expensive than carbon steels but have slightly better qualities, are used as a compromise. Corrosion-resisting materials, nitriding and miscellaneous metals are discussed and economics of operation are given. (9)

Experiences with Pipe Line Systems of a Steel Mill in the Ruhr District. (Erfahrungen an Rohrleitungen eines Hüttenbetriebes im Ruhrgebiet.) R. Neumann. *Stahl und Eisen*, Vol. 50, Aug. 7, 1930, pages 1127–1131.

Experiences of all kinds with steam, water and gas lines are discussed and recommendations are made as to new constructions. Materials, dimensions, valves, joints, gaskets, expansion, protection against destruction and repairs are considered. GN(9)

The Development of Rigid-Airship Construction. V. C. Richmond. *Engineering*, Vol. 130, Sept. 12, 1930, pages 341–344.

Paper read before Section G of the British Association at Bristol, Sept. 8, 1930. LFM(9)

Principles and Uses of Wire Rope. Part VII. Walter A. Scoble. *Metallurgia*, Vol. 2, June 1930, pages 63–64.

Methods for producing a wire rope that will not twist under tension, and the core materials used are considered. JLG(9)

Mercury-Vapor Unit A Commercial Success. T. H. Soren. *Electrical World*, Vol. 96, July 5, 1930, pages 35–37.

Seven years' experience with the mercury-vapor process at the plants of the Hartford Electric Light Co. proves conclusively that this method is sound in theory and practice. Electrical energy is being commercially produced upon a fuel consumption of 0.7 lb. of first-class bituminous coal per net kilowatt-hour which is equivalent to about 10,000 B.t.u. per kw. hr. No cases of mercurial poisoning have developed in the past 6 years. It appears likely that present coal rate will be reduced by further development and a much greater capacity produced from approximately the same investment cost. Several illustrations are included. WHB(9)

Rolled Gold: Its Origin and Development. Ernest A. Smith. *Institute of Metals, Advance Copy* No. 539 (1930) 25 pages.

Rolled-gold according to the British legal definition is a material made by sweating or soldering a sheet of gold or a gold alloy to a base metal and rolling to form a plate having a gold surface on one or both sides, or in the case of wire reducing to form an article having a gold surface and a base metal core. The history of the rolled-gold industry is discussed. Rolled-gold was probably developed in England about a hundred years ago. Since 1841 it has had to compete with electro-gilded articles, but the rolled-gold is much more durable and is used for the better class of imitation jewelry. Contains 21 references. JLG(9)

The Plating on Radiator Shells. Oliver P. Watts. *Preprint* 58–14, *American Electrochemical Society*, Sept. 25–27, 1930, pages 187–205.

Photographs of the plating on radiator shells are shown, accompanied by a description of the preparation of the steel and the details of plating. Heavy electrodeposits on steel are prescribed, to insure lasting protection against corrosion. The proper preparation of the steel surface preliminary to plating is an important factor. The actual thickness of various copper, nickel and chromium deposits was determined microscopically. Tests were made for pin holes and cracks in the plates. Finally samples were immersed in a 35-g./l. NaCl solution. Many specimens were in good condition after 23 days' immersion. (9)

HEAT TREATMENT (10)

Heat-Treatment—Electric Furnace for Duralumin Sheet. Robert J. Anderson. *Metallurgia*, Vol. 2, May 1930, pages 1–3.

A furnace for the heat treatment of duralumin sheet, built by the Gas Equipment Engineering Co. for the Fairmont Aluminum Co., is described. The furnace is of the resistor (Nichrome) type. It has a movable bottom with a sand seal. The sheets are suspended on a rack, which can be lowered into the quenching tank directly below the furnace. Heat treatment costs, including labor, are estimated at 0.33 cents per pound. JLG(10)

Effect of Repeated Annealing and Quenching on the Aging Properties of Duralumin. (Einfluss wiederholten Ausglühens und Abschreckens auf die Veredelungsfähigkeit von Duralumin.) K. L. Meissner. *Metallwirtschaft*, Vol. 9, Aug. 8, 1930, pages 661–662.

Test bars of No. 681 B alloy were heat treated repeatedly, up to 25 times, by heating to 510–520° C., quenching in water and aging for 5 days to determine whether the physical properties changed. Repeated heat treating is sometimes necessary in practice, especially in the case of riveted structures. Brinell hardness, yield point, tensile strength, elongation, ductility and bend tests were made and results are given in curves. No change takes place after repeated heat treatments. Brinell is from 119 to 122, yield point 26-28 kg./mm.^{2} (36,900–39,700 lbs./in.^{2}) tensile strength 40–42 kg./mm.^{2} (56,800–59,600 lbs./in.^{2}) and elongation 18–22%. CEM(10)

Hardening (10a)

On the Influence of the Shape of Cementite in Carbon Steels on the Sensitivity to Heat, the Tendency for Deep Hardening and the Formation of Hardness Cracks. (Ueber den Einfluss der Zementitformen auf die Feuerempfindlichkeit, die Neigung zur Durchhärtung und die Härterissbildung von Kohlenstoffstahl.) S. Steinberg. *Stahl und Eisen*, Vol. 50, Aug. 14, 1930, pages 1164–1166.

After outlining the theoretical principles of the favorable influence of globular pearlite in quenching straight carbon steels, the results of hardness tests on 2 steels (*a*) C 0.08%, Si 0.16%, Mn 0.38% and (*b*) C 1.33%, Si 0.17%, Mn 0.46% are given. The final conclusions are that failures in hardening are related essentially to an insufficient heat treatment. Failures from burning, insufficient depth of hardness and cracks occur mostly in steels with a lamellar pearlitic structure. Globular crystallized cementite improves the steel quality. GN(10a)

Annealing (10b)

Normalizing. *Metallurgist*, Nov. 1929, pages 166–167.

One of the most recent developments of heat treatment in the steel industry of America has been the continuous normalizing of steel in the form of uniform, relatively thin, sections such as sheets and strips of low-carbon steel. The advantages of this process and the design of furnaces for carrying it out are described. (10b)

Case Hardening & Nitrogen Hardening (10c)

Gaseous Cementation of Iron and Steel. VI. The Nature of the Diffusion of Carbon. Arthur Bramley & Harry Dennis Lord. *Carnegie Scholarship Memoirs*, Vol. 18 (1929) pages 1–29, 13 references.

Bars of the same steel carburized to the same extent initially were reheated for a definite period at the same temperature in atmospheres of H_2, N_2 and in vacuo. The redistribution of C was the same in all cases. The results support the theory of solid diffusion of C in Fe. A slight loss of C was found after the reheating, though it did not account for the total loss in weight of the piece. An explanation for the additional loss was the removal of dissolved gases and the reduction of dissolved oxides of Fe with the formation of volatile oxides of N_2. The diffusivity constant for C in Swedish Fe was calculated to be 18×10^{-1}, while for Armco Fe the value varied from 11×10^{-8} to 15×10^{-8}. Abnormalities in Armco Fe are due to the presence of oxide. (10c)

The Cementation by Sodium Cyanide. (La cementation au cynaure de sodium.) B. Jousset. *Aciers Speciaux, Métaux et Alliages*, Vol. 5, Jan. 1930, pages 15–26.

A new process of cementation is described. It consists in introducing the material to be hardened in a bath of 75% sodium cyanide, and 25% sodium carbonate, held at 875° C. The depth of hardening depends on the composition of the bath, the nature of the steel to be hardened, temperature and the time. The depth of penetration increases rapidly for the first hour of cementation and after that a slow gradual increase takes place up to 5 hours time. This is illustrated by the curves given. GTM(10c)

Nitrogen Surface Hardening. *Metallurgist*, Sept. 1929, pages 139–140.

A review of articles in current engineering periodicals. The original nitriding process, as set forth by Fry, involves treatment of steel containing chromium and aluminum in ammonia for 90 hours at 510°, or not exceeding 580° C. McQuaid pointed out that the addition of a small quantity of molybdenum to steel materially reduced notch brittleness of nitrided parts. The application of the nitriding process to motor cylinder and liners is discussed. Homerberg recently determined the hardness of nitrided surfaces at elevated temperatures. (10c)

Cementation and Uses of Nickel Steels. (La cêmentation et l'emploi des aciers au Nickel.) W. T. Griffiths. *Aciers Speciaux, Mêtaux et Alliages*, Vol. 5, April 1930, pages 146–156, 8 references.

A general description of the effect of Ni on the physical and mechanical properties of steel. The following specification is given for nickel steel used for carburizing: C less than 0.11%; Si less than 0.30%; Mn 0.20–0.30% S 0.05%; P 0.05%; Ni 2.50–3.50% (in 3% Ni steel) and 4.50–6% (in 5% Ni steel); Cr less than 0.30%. The carburization of this type of steel is carried out at a temperature not higher than 900° C. This steel requires only one treatment, that is oil quenching from 760° C. but if the manganese content increases over 0.60% a much higher quenching temperature is required in order to obtain better mechanical properties. Ni-Cr steel used for carburizing contains 0.10–0.20% C, 0.10–0.25% Si, 0.20–0.50% Mn, 3.50–4.50% Ni and 1.0–1.50% Cr. GTM(10c)

Quenching (10d)

Quenching of Alclad Sheet in Oil. Horace C. Knerr (Metallurgical Laboratories, Inc.). *American Institute Mining & Metallurgical Engineers, Preprint* Sept. 1930, 5 pages.

Alclad sheet and ordinary duralumin were quenched in both oil and water. Samples were then subjected to the alternate immersion test. The oil quenched duralumin failed rapidly, as was to be expected, but the oil quenched alclad sheet was as good as the water quenched sheets. Alclad sheets are duralumin coated with high purity aluminum. JLG(10d)

Drawing (10e)

Influence of Drawing on the Expansion and Hardness of Hardened Aluminum-Silicon Alloys. (Influence du revenu sur la dilatation et la dureté des alliages aluminum-silicium trempés.) Pierre Chevenard & Albert Portevin. *Comptes rendus*, Vol. 191, Aug. 4, 1930, pages 252–254.

Dilatometric study of aluminum-silicon previously drawn at 525°. Below 100° the precipitation of the silicon is very slow and the effects of an 8-hour drawing hardly perceptible; between 200–350° an 8-hour drawing suffices to precipitate all the silicon, beyond 350° there is no solution again. Annealing between 150–200° definitely increases the hardness which depends on the time of the precipitation of the silicon and on the fineness of texture; this, in turn, diminished with increase in temperature. Solution of the silicon is accompanied by a contraction; precipitation is accompanied by an expansion increasing with the quantity of the silicon freed from the solid solution. W(10e)

Aging (10f)

Age Hardening Aluminum Alloys. (Vergütbare Aluminiumlegierungen.) W. Fraenkel. *Zeitschrift für Metallkunde*, Vol. 22, March 1930, pages 84–89.

By means of a simple Al alloy with small Cu addition the characteristics of the age-hardening phenomenon and its course at ordinary, elevated and alternating temperatures are considered and theoretical derivations made alongside constitutional diagrams. More complex systems are tackled at the hand of some representative alloys. Paper was read at the Meeting of the Deutsche Gesellschaft für Metallkunde, Sept. 1929, Düsseldorf. EF(10f)

The Aging Process in Zinc-Copper Alloys. (Ueber den Vergütungsvorgang in Zink-Kupferlegierungen.) M. Hansen. *Zeitschrift für Metallkunde*, Vol. 22, May 1930, pages 149–154, 17 references.

The aging process in Cu-Zn alloys quenched from the β-field in the range 61.0 to 54.3 at.% Cu was studied by means of electric resistance measurements. These alloys, which transform from β-brass to an $(\alpha + \beta)$ brass on aging, were thought especially suited for study by electric methods since the space lattice of β-brass shows a regular distribution of atoms (CsCl structure) whereas the precipitate, α-brass, shows a random distribution of atoms, and since the electric resistance of the homogenized $(\alpha + \beta)$ alloy is greater than that of the pure β. Both these conditions are opposite to those usually obtained in age-hardening alloys. Four alloys were studied with, respectively, 59.15%, 59.74%, 59.93% and 60.58% Cu. Aging was performed at temperatures between 150 and 400° and time resistance curves drawn. At sufficiently high temperatures (350–400°) the resistance changed with time in the direction expected, i. e., it increased gradually to a constant end-value, but at temperatures of 250° and below there occurred at first a sudden increase, then a period in which no change occurred, and finally a slow increase to a maximum value followed by a slow decrease to the final value. It is thought that the sudden increase is brought about by a lattice change which is not directly related to the age-hardening. This lattice change may be a change in the distribution of Cu- and Zn atoms upon the β-lattice. The second rise in resistance is caused by precipitation which at low temperatures displays a period of induction. As a result of the high dispersion of the precipitate and the resulting inner strains an "anomalous" resistance increase obtains which gives a resistance value greater than that representing the end-value for homogenized alloys at the temperature concerned. With longer time a decrease in resistance naturally occurs. EF(10f)

On the Age-Hardening of Some Magnesium Alloys. S. Hashimoto. *Kinzoku no Kenkyu*, July 1930, pages 371–378.

Many binary alloys of magnesium and some ternary alloys containing Mg, Al and another metal were investigated. The results showed that, among the binary alloys tested the Mg-Al and Mg-Zn alloys were found to show age-hardening. The Mg-Al alloy containing 10% Al can be age-hardened up to a Brinell number 90. The alloy containing 6 or 4% of Al cannot be age-hardened, but the mechanical properties can be made uniform by the age-hardening. No better results were obtained by adding another metal to the binary alloy Mg-Al. KT(10f)

Theory of the Age-Hardening Process Based on the Investigation of Beryllium-Copper Alloys. (Zur Theorie des Vergütungsvorgänge auf Grund der Untersuchungen an Beryllium-Kupferlegierungen.) G. Masing. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 187–196.

All the phenomena associated with the age-hardening of Be-Cu alloys can be explained on the assumption that a second phase is precipitated in a highly dispersed form by the decomposition of a supersaturated solid solution. 13 references. (10f)

Changes in the Microstructure of Beryllium-Copper Alloys Due to Age-Hardening. (Aenderungen des Aetzgefüges der Beryllium-Kupferlegierungen durch die Vergütung.) G. Masing & O. Dahl. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 149–153.

During the aging of Be-Cu alloys at 350° the α-crystals and β-crystals on etching with ammoniacal $CuSO_4$ solution show a series of crystallographically regularly oriented lines which gradually increase in number and intensity. This phenomenon is ascribed to the gradual precipitation of γ from supersaturated α and from the breakdown of the β-phase. The lines are most intense when the hardness is at a maximum; further heating results in their slow disappearance. (10f)

Changes in Electrical Conductivity and Volume of Beryllium-Copper Alloys During Age-Hardening. (Aenderungen der elektrischen Leitfähigkeit und des Volumens bei der Vergütung von Beryllium-Kupferlegierungen.) G. Masing & O. Dahl. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 126–141.

Aging of quenched Be alloys results in considerable changes in the conductivity; with alloys containing less than 3% Be there is an initial fall followed by a more or less sharp rise. At 350° the conductivity is doubled by sufficiently prolonged tempering. Aging also causes a progressive contraction in which the volume change amounts to a maximum of 0.6% with the 2.5% Be alloy tempered at 250° for 81 hours. 3 references. (10f)

Changes in the Modulus of Elasticity During Age-Hardening of Beryllium-Copper Alloys. (Ueber die Aenderung des Elastizitätsmoduls bei der Vergütung von Beryllium-Kupferlegierungen.) G. Masing & C. Haase. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929) pages 142–148.

The torsion modulus of Be-Cu alloys increases during aging in a manner similar to the electric conductivity. This is in accordance with the theory that the age-hardening of these alloys is due to precipitation of the γ-phase in a highly dispersed state. (10f)

Age Hardening of "Constructal." (Ueber die Vergütung einer Constructallegierung.) G. Wassermann (Kaiser Wilhelm Institut für Metallforschung, Berlin-Dahlem). *Zeitschrift für Metallkunde*, Vol. 22, May 1930, pages 160–162, 8 references.

Measurements of hardness and space lattice constant were made in the Zn-Mg alloy "Constructal." EF(10f)

Age Hardening Alloys of Heavy Metals, Except Precious Metals. (Vergütbare Schwermetallegierungen mit Ausnahme der Edelmetalle.) G. Masing. *Zeitschrift für Metallkunde*, Vol. 22, March 1930, pages 90–94, 17 references.

Encouraged by the age-hardening of Al alloys, the prerequisites for the utilization of dispersion hardening in heavy metal alloys is discussed. The most important alloys of commercial significance, the Heusler, Corson and Be-alloys are described. Age hardening of Fe-C, Cu-Ag and Mg-Cu was accomplished but clear theoretical explanations are still lacking. The paper, which emphasizes physical properties of the alloys discussed, was presented before the Deutsche Gesellschaft für Metallkunde, Sept. 1929, Düsseldorf. EF(10f)

Age Hardening Precious Metal Alloys. (Vergütbare Edelmetallegierungen.) L. Nowack. *Zeitschrift für Metallkunde*, Vol. 22, March 1930, pages 94–103, 21 references.

The author considers in his paper alloys the main element of which is Au, Ag or a metal of the Pt-group. In the following systems age-hardening by segregation is possible: Ag-Cu, Ag-Cu-Cd, Au-Ni-Si, Au-Ni-Al, Au-Pt-Zn, Au-Pd-Zn. The writer furthermore performed age-hardening in alloys of 75% Au and 25% Pt and in Fe-Au alloys containing 15–20% Fe. The commercially important Au-Ni alloys are also subject to age-hardening due to the decomposition of a solid solution with 10–90% Ni. Further, alloys introduced by Corson consist of a precious metal and 3 or more other metals. A new type of age hardening ability was observed in the binary system Au–Cu at 50 atomic % Au which shows a solid solution stable at elevated temperatures and which decomposes on cooling into intermetallic compounds. Similar conditions prevailing in alloys of Cu with Pd and Pt are discussed. EF(10f)

Malleablizing (10g)

Packing Materials in the Malleable Iron Foundry. T. Kikuta. *Kinzoku no Kenkyu*, Sept. 1930, pages 487–504.

In making malleable cast iron without packing materials, the oxidised carbon content was measured from the amount of the evolved gas and it was found to be less than 0.1% C; heating for more than 7 hours was not necessary. In annealing white cast iron, the required decarburization was completed by 4% of iron oxides for the white cast iron. The best decarburizing effect was obtained when hematite was used. If iron oxide was used for packing material, the decarburization increased with rising temperatures logarithmically. The good effect of adding another oxidizing agent such as sodium nitrate to the iron oxide was not noticeable. The strength of malleable cast iron, which was heated with 5% iron oxide, was about 10% greater than that treated without oxide. The thermal conductivities of iron oxide (scale) and sand between 250 to 400° C. were measured to be 0.0006603 and 0.0008148 cal./deg./cm.^{3}, respectively. KT(10g)

JOINING OF METALS & ALLOYS (11)

Brazing (11a)

Metals Suitable and Unsuitable for Copper Brazing. *American Metal Market*, Vol. 37, Aug. 30, 1930, pages 5, 10.

In general, most of the ferrous metals can be brazed in hydrogen satisfactorily. Stainless steels containing chromium are an exception. Nickel and copper have a strong affinity and brazing of low-nickel-steels is possible. Monel metal cannot be brazed easily, tungsten, molybdenum and tungsten carbide alloys braze satisfactorily. WHB(11a)

Soldering (11b)

Production of Soldering Wires for the Rare Metal Industry. (Die Herstellung von Lotdrähten für Edelmetallindustrie.) Karl B. Thews. *Deutsche Goldschmiede-Zeitung*, Vol. 33, April 5, 1930, pages 164–165.

Discusses the production of self-soldering wire, that is wire having a core of solder and a shell of gold or silver. The compositions of some generally used gold and silver solders are given. JLG(11b)

Welding & Cutting (11c)

Welding in Chemical Engineering. J. R. Booer. *Journal Society of Chemical Industry*, Vol. 49, Jan. 10, 1930, pages 17T–21T; *Chemical Age*, Vol. 22, Jan. 18, 1930, pages 47–48.

Reviews general considerations from the physical and chemical points of view, and summarizes the behavior of Al and its alloys, Cu, brass, bronze, Cr and Cr steels, Fe, steel, Pb, Monel Metal, Ni and Zn. (11c)

Arc-Welding in Construction of Machinery. (Lichtbogenschweissung im Werkzeugmaschinenbau.) E. Rosenberg & W. Senft. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. 22, 1930, pages 225–230.

The author illustrates by many examples the possible saving in the manufacture of heavy machines, lathes, boring stands, etc., by using arc-welded structural steel instead of cast parts. Ha (11c)

Soldering and Welding Light Alloys. (Das Löten und Schweissen der Leichtmetalle.) L. Rostosky. *Metallwirtschaft*, Vol. 9, June 13, 1930, pages 499–502.

Al and Mg alloys both form a thin coat of oxide immediately on freshly cut surfaces, and they both corrode easily when exposed to air or moisture. Al can be soft soldered with solder containing little or no Al. Usually a Zn alloy containing Cd, Pb and Bi and 0–20% Al is used. Melting point of these alloys is 150–450° C. A flux is not used generally, but the surfaces to be soldered are scraped with the solder or iron. The soldered joint becomes dark in color and corrodes in air and moisture. This can be prevented by some protective coating. Soft soldering has the advantage of being easy to apply and high heat is not necessary. Hard soldering of Al alloys has been developed more recently. The solder consists of 70–95% Al alloyed with Cu, Ni, Ag, Mn, Sn, Cd, Si, Cr or Ti. Working temperature 540–630° C. This forms a corrosion proof joint of good color. Al-alloy solder is better than pure Al as the melting point is lower and extends over a larger range whereas pure Al sets suddenly. Formerly alkali and alkaline earth halides were used as a flux, but Be salts are found to be better. Great care must be taken to remove the excess flux as it attacks the metal. Hard soldering is easier to apply than welding and is especially suitable for thin sheets. It is used to plug holes in castings and for joining parts in construction work. The tensile strength of Al alloys is reduced by both soft and hard soldering. Gas or acetylene with compressed air or oxygen are used for heating, also methane and hydrogen. Al alloys can be hammer welded after heating to about 420°C. The surface must first be scraped and even then a very thin film of oxide is forced into the weld, but the results are very good. Welding is particularly suitable for larger pieces, but is slower than soldering, is more difficult to do and requires more experience. Autogenous gas welding is quicker. A flux is used in this case. Acetylene, hydrogen, gas and benzol can be used. The acetylene must be free from impurities. Resistance and arc welding have been used to a limited extent. Elektron metal can be soft soldered in the same way as Al alloys. The solder used contains a higher percentage of Cd. Hard soldering has not been developed for Mg alloys. Fluxes containing chlorides attack Mg, but other fluxes have been developed. Welding of Mg alloys has not been fully developed, and some alloys cannot be welded. CEM(11c)

The Progress of Arc Welding. Edward Dacre Lacy. *Metallurgia*, Vol. 2, June 1930, pages 61–62, 64.

The application of arc welding to ship building and repairing is discussed. Instances are cited to prove that arc welded construction is at least as good as riveted construction. JLG(11c)

Gas Welding Chrome-Nickel Steel. H. S. Lancing. *Welding Journal*, Vol. 27, May 1930, page 147.

The results of the work are expressed as being hardly satisfactory. A summary of the welding method is presented as follows: use a small tip, a neutral or, preferably, reducing flame; make ample allowance for contraction; weld from one side only, with the flame constantly on the melted metal; watch penetration closely. AWM(11c)

Welding Facts and Figures. XLVI. Handbook for Welding Engineers. D. Richardson & E. W. Birch. *Welding Journal*, Vol. 27, May, 1930, pages 134–135.

An article on magnesium and magnesium alloys bringing out the fact that it has been found possible to weld magnesium by using a highly reducing flame. The physical properties of magnesium are given. Corrosion is the barrier to more rapid adoption. Paints, varnishes, etc. have been found ineffective as protection against sea water. Cellulose enamels have yielded the best protective results to date. AWM(11c)

Autogenous Welding of Different Metals. (Vom Autogenschweissen der verschiedenen Metalle.) Hans Steger. *Zeitschrift für Feinmechanik und Präzision*, Vol. 38, Aug. 15, 1930, pages 7–8.

Not all metals can be welded in the same manner as iron due to their different properties when in the molten state. Nickel and aluminum for instance require a hammer welding process with the application of certain solders which absorb gases. The so-called light-metals can all be welded. The article describes the suitable methods for different alloys. HA(11c)

Electric Arc Welding. L. S. Thurston. *Electrician*, Vol. 105, Aug. 22, 1930, pages 225–226.

Developments in the U. S. A. during 1929 and the growing use in building and on long pipe lines are indicated. WHB(11c)

Strength of Welded Joints in Tubular Members of Aircraft. H. L. Whittemore & W. C. Brueggeman. *Report* No. 348, *National Advisory Committee for Aeronautics* (1930) 41 pages.

This investigation was undertaken to make available to the aircraft industry authoritative information on the strength, weight and cost of welded joints of a number of types. Chromium-molybdenum tubing was oxyacetylene welded under procedure control. Following a program prepared from information supplied by manufacturers, 40 joints were welded under procedure specifications and tested to determine their strength. It was found that the point of minimum strength and hardness of the base metal is sharply defined and is located about $1/2$ inch from the weld center. If a T joint is loaded to high bending stresses near the joint, it is more satisfactory to gain strength by increasing the size of the tube rather than by adding plates, straps or the like. Reinforcement by means of U straps increases the efficiency to 87% A joint can be made almost as efficient by welding large gussets between the intersecting tubes, but the weight and the time required to fabricate are excessive. The best reinforcement for the lattice joint is one that reinforces it against collapse of the tube. Cracking is an important problem when gusset plates are used for reinforcement. A procedure for welding each type of joint should be worked out experimentally, and designs which cannot be welded consistently without cracking should be discarded. (11c)

Tips on How to Weld Galvanized Sheet Iron. *American Metal Market*, Vol. 37, Aug. 29, 1930, page 10.

From "Better Welds with Armco Ingot Iron" published by American Rolling Mill Co. For arc welding, the jaws of the jigs should be as close to the edges to be welded as is physically possible for good operation and should press the metal tightly enough to prevent excess expansion and contraction. Absorption of evolved zinc is overcome by seeing that the arc is oscillated. A welded surface of galvanized iron should be painted after thorough wire-brushing. WHB(11c)

How to Weld Nickel. *Canadian Mining Journal*, Vol. 51, June 27, 1930, pages 628–629.

A reprint of a paper from "*Acetylene Tips*" showing that sound welds in nickel are made by the oxy-acetylene process when proper methods are used. A table shows a welding chart of the sizes of welding tips or heads to be used on the various types of Oxweld welding blowpipes for the different thicknesses of nickel. A high-grade flux, and a reinforcement of the finished weld to allow for grinding are essential to secure satisfactory welds. WHB(11c)

The Welding of Copper. *Chemical Engineering & Mining Review*, Vol. 22, July 5, 1930, page 380.

Research work at the Imperial Chemical Industries, Ltd. has resulted in the perfection of a simple welding method for copper. But slight modification of ferrous metal welding technique is required. A copper alloy filler rod and an appropriate flux are employed. The filler rod is of specially modified copper, which is very fluid when molten. WHB(11c)

Welding Copper. *Metallurgia*, Vol. 2, May 1930, page 6.

A satisfactory method for welding copper with acetylene torch has been developed. A special copper alloy filler rod and a special flux are used. JLG(11c)

Electric Rivet Cutting Brings Railroad Economies. *Electrical World*, Vol. 96, Sept. 13, 1930, pages 483–484.

Electric cutting of rivet heads for railroad car repairs has superseded acetylene cutting in Chesapeake & Ohio car shops at Raceland, Ky. due to greater speed and at half the cost. The cutting equipment includes one induction-motor-driven d.c. generator and two synchronous motor generator sets. Electricity removes old rivets and heats the new rivets for driving Energy consumption of $18^{3}/_{4}$ kw.-hrs. for 100 lbs. of rivets is claimed Electric heating of rivets is cleaner and more convenient. WHB (11c)

Cutting Through Five Feet of Cast Steel. *Iron Age*, Vol. 125, April 24, 1930, page 1230.

Describes method of scrapping a 55 ton steel anvil of a steam hammer. An oxygen lance was used with which a cut 62 in. deep and 7 ft. long was made. Oxy-acetylene blow pipe was used to open the kerf ahead of the lance. VSP(11c)

Welding of Rust-Resisting Steels. *Metallurgist*, Oct. 1929, pages 147–149.

A review of a paper presented by H. Bull and Lawrence Johnson before the British Acetylene and Welding Association of London, reprinted in Brown Bayley's Journal Practical information on the method of operation. For high-nickel high-chromium steels, exposure to welding heat whether followed by slow or rapid cooling produces no very marked effect on the mechanical properties. Need of heat treatment after welding. *International Nickel Co. Abstract Bulletin* (11c)

Preheating Practices. *Oxy-Acetylene Tips*, Vol. 8, March 1930, pages 181–188; *Welding Journal*, Vol. 27, May 1930, pages 141–145.

The correct procedure for preheating metals commonly encountered in welding is given. Preheat cast iron, cast aluminum, monel metal and pure nickel castings, bronze castings if large. Cast steel does not require preheating, unless thick walls would result in localized heat which would set up strain. Preheating should be resorted to before cutting alloy steels with the blowpipe. AWM(11c)

Welding of High-Chromium Alloys. *The Steel Founder*, Vol. 1, May 1930, pages 8–10.

These alloys can be welded under proper conditions and with proper procedure. Due to the formation of infusible oxides the ordinary fluxes are not satisfactory, but best results are obtained by using a special flux designed for welding high-chromium steels. Discusses methods of welding 5 groups of these steels: (1) Rustless iron (C, less than 0.12%; Cr 12–15%). (2) Stainless steel (C, over 0.30%; Cr, 11–17%). (3) Rustless iron or Stainless iron (Cr, 17–25%; Ni, 7–9%). (4) Special steels (Ni, 17–22%; Cr 7–25%). (5) Extra High Cr Alloys (Cr, 24–30%; C, less than 0.30%) Discusses briefly the welding of high-chromium castings. MLM(11c)

Report of the Committee on Welded Containers. Department of Scientific and Industrial Research. H. M. Stationery Office, London. Obtainable from British Library of Information, 5 E. 45th St., New York. 1s. 3d., 1930, 51 pages.

For welded pressure vessels such as drums and tank cars for transport of chlorine, phosgene, sulphur dioxide and ammonia, open-hearth steel of 0.10–.20% C, 0.40–0.60% Mn and maxima of 0.04% S, 0.05% P, 0.20% Si is specified. Tensile strength 44,000–53,000 lbs./in.^{2}, elongation 27% in 8 in. Bend test, 180° over a radius equal to the thickness of the specimen. Dimensions and wall thickness of the containers are specified. Forge welding without addition of any material as from a welding rod is required. Heating with water-gas fuel is approved as it does not bring the metal to fusion. Fusion welds, either electric or oxyacetylene, are not approved for this purpose. Overheating is to be avoided, no forging done below 800° C. and the welded vessel heated to 950° C. and cooled in still air. Hydraulic tests and drop tests (for drums only) are specified. Filling and working pressures for the 4 gases are given. Appendices deal with drop tests, rough handling tests and Izod tests on which the preference for forge welding is based. HWG(11c)

WORKING OF METALS & ALLOYS (12)

Melting & Refining (12a)

A Study on Velocity of Reaction and Behavior of Equilibrium in Melting Steel. (Untersuchungen über die Reaktionsgeschwindigkeit und das Gleichgewichtsverhalten beim Stahlschmelzen.) W. Hessenbruch. *Stahl und Eisen*, Vol. 50, Aug. 7, 1930, pages 1133–1134.

W. Hessenbruch reviews Scandelin's paper in Jernkontorets Annaler, Oct. 1929, pages 519–544, as abstracted in *Metals & Alloys*, April 1930, page 475. GN(12a)

Extra-Mild Open-Hearth Steel. (Les aciers extra-doux élaborés au four Martin.) G. B. Bruno. *Aciers Speciaux, Métaux et Alliages*, Vol. 4, Oct. 1929, pages 462–464.

The author discusses the preparation of this steel and the causes of the defects that may be encountered. (12)a

Medium Carbon-Manganese Steel. (L'Acier $^1/_2$ dur 55/65 Kilogs de resistance a teneur élevee on Manganese.) E. Decherf. *Aciers Speciaux, Métaux et Alliages*, Vol. 5, Feb. 1930, pages 51–65.

Investigations on medium carbon-manganese steel made in an open-hearth and electric furnace. The carbon content of the steel was about 0.30% and the manganese 1.20–1.50%. A detailed log of heats is given. Microstructure examinations showed a less pearlitic structure in medium manganese steel compared with a low carbon steel. This steel proved to have good resistance to wear. Forging of this steel can be done at 950° C. GTM(12a)

Electric Heat in Newspaper Production. J. H. Faulkner & P. H. Clark (Commonwealth Edison Co., and General Electric Co., respectively). *Electrical World*, Vol. 96, Sept. 13, 1930, pages 488–492.

Electrical heat has been applied in the melting of line castings and stereotyping, remelting of slugs and scrap, heating of flat work castings, and making electrotype baths and wax tables. Chief among the advantages are better working conditions, more efficient utilization of space, automatic temperature control, uniform heat, flexibility, high speed and less wastage. WHB(12a)

Open Hearth Steel. E. Killing. *Iron & Coal Trades Review*, Vol. 120, Feb. 7, 1930, pages 246.

Abstract translation of an article "Distinction between Solid and Molten Pig Iron Charges in Open-hearth Furnaces" in *Stahl und Eisen*, Dec. 1929, pages 1821–1827. See *Metals & Alloys*, Vol. 1, Sept. 1930, page 736. RHP(12a)

A Contribution to the Problem of the Analysis of Basic Slags and the Representation of Their Composition in a Triangular Diagram. Otakar Quadrat (Technical University, Praha). *Iron & Steel Institute, Advance Copy* No. 5, Sept. 1930, 9 pages.

In analysis of open-hearth slags an error usually results from the reduction of ferric oxide by the sulphide liberated on acid treatment. Accurate methods are described for the determination of both the ferric iron and the sulphur. Results of the analysis of 25 open-hearth slags are plotted on a special ternary diagram where the corner A (total bases) = $CaO + MnO + FeO$, B (total acids) = $SiO_2 + P_2O_5$ + sulphidic sulphur + SO_3 and C (oxides of the R_2O_3 type) = $Al_2O_3 + Fe_2O_3$. Other methods of plotting data are criticized. Contains 5 references. JLG(12a)

Investigation on the Composition of the Open Hearth Bath at Various Bath Depths. (Untersuchung über die Badzusammensetzung von Siemens-Martin-Schmelzungen in verschiedenen Badhöhen.) S. Schleicher. *Stahl und Eisen*, Vol. 50, July 24, 1930, pages 1049–1061, 8 references.

Report No. 189 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute. Includes discussion. It was possible to study the reactions in different depths of steel baths by inserting steel bars, covered with lead sheets, and drawing samples. It was stated that remarkable differences for phosphorus and sulphur are observable. Copper is dissolved uniformly. Chemical reactions between slag and steel spread very fast from the surface of the bath to the hearth, Also the composition of the slag varies at different locations; these differences are especially large after adding ferro-manganese. The contents of magnesia show the biggest discrepancies. GN(12a)

The Refining of Ferrochrome in the Coreless Induction Furnace. (Das Feinen von Ferrochrom im kernlosen Induktionsofen.) C. Tama. *Archiv für Eisenhüttenwesen*, Vol. 14, Aug. 1930, pages 55–61; *Stahl und Eisen*, Vol. 50, Aug. 28, 1930, page 1232.

Report No. 190 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute. The melts were made in coreless induction furnaces with 250 and 750 kg. capacity. The decarburization was studied, while refining the melts either with air or ore, for variable pressures and temperatures. Furthermore, the influence of various oxidizing slags was investigated. The disadvantages of air refining are loss of chromium and picking up of nitrogen. Basic slags with additions of purple ore gave the best results. It is easier to refine a melt with 30% chromium than one with double that amount of chromium. In order to produce low carbon ferro-chrome the application of the duplex process is necessary. Carbon bearing ferrochrome is processed in the arc furnace and refined in the coreless induction furnace. The economy of the refining depends upon the life of the hearth of the furnace. Ferrochrome is most favorably refined in furnaces with linings of either chromite or magnesia. The progress of the decarburization is illustrated by microphotographs. The known stable chromium carbides and iron-chromium carbides can be detected in these pictures. GN(12a)

The Desulphurization in the Basic Open-Hearth Process. (Die Entschweflung beim basischen Siemens-Martin Verfahren.) K. Koehler. *Stahl und Eisen*, Vol. 50, Sept. 4, 1930, pages 1257–1266.

Report No. 191 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute. Including discussion. After reviewing former investigations on the desulphurization of steel melts the author gives the results of his own investigations, which were carried on especially to study the influence of various amounts of limestone and manganese in the charge. He found that, contrary to the general opinion, the desulphurization strictly depends on the content of CaO in the slag. There is no clear relationship between the manganese content of steel and slag and desulphurization. A decrease of manganese in the charge below the common values has no disadvantage on the desulphurization whereas exceedingly high amounts of manganese favor the desulphurization. A chemical explanation of the test results is finally briefly discussed. GN(12a)

The Production of High-Test Cast Iron. Richard Moldenke. *Preprint* 58-27, *American Electrochemical Society*, Sept. 25–27, 1930, pages 385–401.

he advent of high-test cast iron marks the beginning of a new chapter in foundry metallurgy. Very high melting temperatures greatly improve the strength of cast iron. The electric furnace methods and product are compared with those of fuel-fired furnaces. (12a)

The Loss of Metallic Iron in the Converter Slag of Thomas Steel. (Ueber die Eisenverluste beim Thomasverfahren als metallisches Eisen in der Konverterschlacke.) M. Paschke & A. Gockowiack. *Stahl und Eisen*, Vol. 50, Aug. 21, 1930, pages 1199–1201.

It was determined whether the iron loss in the basic converter is due to an emulsion of steel particles of the steel bath during the air blast or if this loss of metallic iron which in the examined slag ranged from 0.28–0.40% metallic iron, is due to other causes. This iron loss was found to be due to mechanical causes. According to the methods used up to the present time, it is impossible, by tilting the converter, to determine exactly the time when the slag is tapped completely and steel starts flowing. Besides a careful supervision of the tapping an electrical supervision instrument is suggested. GN(12a)

A New Method for the Production of Copper Wire Bars. (Ein neues Verfahren zur Herstellung von Kupferdrahtbarren.) M. Tama. *Zeitschrift für Metallkunde*, Vol. 22, June 1930, pages 207–209, 3 references; *Metallurgist*, Aug. 1930, pages 117–118.

On account of experiments described in the paper the author recommends the utilization of the induction furnace for melting of electrolytic copper for casting into copper wire bars. The main advantages are the maintenance of a neutral furnace atmosphere and the easy attaining and holding of the temperature desired for casting. The application of vertical round molds yield some remarkable advantages. The impurities rise to the top and can easily be removed. No tears or oxygen inclusions are encountered along the length of the bars which show a better density. Experiments on a large scale were carried out with 10 tons electrolytic copper. The resulting wires showed physical properties and electric conductivity with the new melting and casting method as good as the customary method and, of course, often better. VVK & EF(12a)

Casting & Solidification (12b)

Modern Steel Pouring Practice. K. R. Binks. *Metallurgia*, Vol. 2, June 1930, pages 45 and 66.

The influence of mold design on the structure of the ingots is discussed, and wide-end-up type of molds are recommended. Molds must be carefully cast from a high grade iron. "Tun-dish" casting, in which an auxiliary ladle having from 4 to 6 nozzles is used, is recommended. Ladles and runners should be cleaned with a vacuum cleaner prior to use. JLG(12b)

Contraction and Shrinkage. (Einiges über Schwindmass und Schwindung.) W. Claus & F. Goederitz. *Zeitschrift für Metallkunde*, Vol. 22, Feb. 1930, pages 62–63.

Aluminum bronzes with 7–10% Al form larger pipes on casting than billets of Sn-bronzes which fact cannot be interpreted on the basis of relative total shrinkage values for the two alloys. On account of their own experiments the authors suggest that the different behavior may be due to the different division of the total contraction between the liquid and the solid state upon the cooling and freezing of the billet EF(12b)

Blow-Holes in Incompletely "Killed" Steel Ingots. Masaji Hirose. *Tetsu to Hagane*, Vol. 16, Aug. 25, 1930, pages 807–814.

Incompletely killed steel ingots were produced by pouring the melts into 4 ingot molds with different thickness and the relation between the position of the blow-holes in the ingot and the mold thickness was studied. As the mold thickness increases the blow-holes near the surface decrease in amount, and concentrate in the bottom of the ingot. From these results and other known facts the mechanism of formation of the blow-hole in the incompletely killed steel ingot, was explained as follows: when the molten steel was poured into the mold the solidification commences from the contact portion to the mold forming the thin solid crust, from which the columnar crystals are developed inward. The outer portion of the crystals are cooled by contact to the mold, while the inner portion is heated by subsequently poured molten steel. When the cooling effect is small, the dissolved gas is separated forming the blow-hole between the columnar crystals, though if the cooling is rapid the separation of gas is shifted inward. Hence the important point for making a good steel ingot is a proper deoxidizing and fairly rapid cooling during solidification. TM(12b)

The Heterogeneity of an Ingot Made by the Harmet Process. Ant. Kriz. *Iron & Steel Institute, Advance Copy* No. 3, Sept. 1930, 16 pages.

The Harmet process is based on the wire-drawing of steel during solidification in the ingot mold. A 33,000 kg. ingot was made by this process, and sectioned longitudinally. The structure was determined by etching and by sulphur printing. The chemical homogeneity was determined by analyzing drillings taken from the cut face. The ingot contained no pipe. The structure varied markedly from center to surface, but the chemical composition was quite uniform. JLG(12b)

Casting in Permanent-Mold Machines. *Mechanical Engineering*, Vol. 52, Aug. 1930, pages 775–776.

The permanent-mold process described in the article is that employed by the Holley machine which uses ordinary cast iron molds, improved by an effective coating to avoid rapid wear of the surface of the molds. The advantage of the permanent mold-machines lies in the elimination of considerable amounts of handling and labor besides better physical properties due to the uniformity of the grain structure produced by the anneal necessary. GN(12b)

Rolling (12c)

Determining Production Times in Rolling Mills by Means of Recording Meters. (Zeitenmessung an Walzenstrassen durch aufschreibende Stromzähler.) K. Veit. *Stahl und Eisen*, Vol. 50, Aug. 28, 1930, page 1233.

The report of a rolling mill production record is given to illustrate the necessity of obtaining reliable figures on the power consumption for determining the production costs of a rolling mill. GN(12c)

PERSONALS

The Nitralloy Corporation has engaged the services of Dr. Victor O. Homerberg as its Technical Director starting November 1st 1930.

Victor O. Homerberg

The Nitralloy Corporation controls through assignment by Aubert & Duval, Fres., Paris, France, the United States patents issued to Dr. Adolph Fry, of the Friedrich Krupp Aktiengesellschaft, of Essen, Germany, and many other patents and applications relating to the production of steels destined for nitriding and the art of nitriding. At the present time its licensees for Nitralloy steel are as follows: Ludlum Steel Company, Watervliet, N. Y.; Firth-Sterling Steel Co., McKeesport, Pa.; Crucible Steel Co. of America, New York City; Vanadium-Alloy Steel Co., Pittsburgh, Pa.; Republic Steel Corporation, Massillon, Ohio. In addition licenses have been granted to the following companies manufacturing steel castings: Duquesne Steel Foundry Co., Coraopolis, Penna; Empire Steel Castings Co., Reading, Penna.; Milwaukee Steel Foundry Co., Milwaukee, Wis.; Massillon Steel Castings Co., Massillon, Ohio; Warman Steel Castings Co., Los Angeles, Calif.; Electric Steel & Mfg. Co., Los Angeles, Calif.

A. H. Tallman, for many years president and manager of Tallman Brass & Metal, Limited, Hamilton, Ont., is forming a company to manufacture bronze and aluminum castings, babbitt metals, etc. Associated with him will be Joseph Medley and George McKnight. Mr. Medley was foundry superintendent and has been with the Tallman Brass Company almost from its inception. Mr. McKnight was sales manager and has been connected with Mr. Tallman for 25 years.

Dr. H. F. Moore, Professor of Engineering Materials, University of Illinois, gave an interesting talk over the radio on Saturday evening, Nov. 1, 1930, on the functions of the modern prophet in forecasting the possibilities of materials of construction. In this, Professor Moore brought out that there is considerable romance in the testing of materials, in knowing that the work is of significance to the millions of men and women who are daily users of materials.

William Piez, European Correspondent of Link-Belt Company, and a brother of Charles Piez, Chairman of the Board, Link-Belt Company, died at Brussels, Belgium, on November 2nd after a week's illness.

G. Van Dyke, Manager of the Special Steels Dept. of Joseph T. Ryerson & Son, has been delivering a number of lectures on alloy steels, tool steels and stainless steels. The lectures usually cover the better part of a day.

The talk and demonstration which was originally prepared for Ryerson salesmen and service men covered two days, but has now been boiled down to about three hours on the lecture and two hours on practical demonstration and instruction including welding. The first gives a general background of the stainless steel alloys and classification of the various analyses, such as high carbon stainless steel, low carbon stainless iron, high chrome stainless iron, chrome nickel stainless iron of the 18-8 type and chrome nickel alloys of the heat resisting type. The various characteristics of these different products are discussed such as corrosion resistance, machinability, formability, weldability, resistance to scaling, etc.

New Metal Periodical

November 1930 marks the appearance of Volume 1, Number 1 of *Lead* published by the Lead Industries Association, 420 Lexington Ave., New York, N. Y.

This first issue contains a number of interesting notes, illustrating and describing applications of lead and lead pigments. The Lead Industries Association invites inquiries on any subject relating to lead.

Dust Collection in the Foundry

In the October 1930 issue of "Better Methods" published by Beardsley & Piper, Chicago, Ill., appears a very interesting article entitled, "Eliminating 'Dirty Competition.'" This article was especially written for "Better Methods" by Ralph J. Hutchinson. Various types of dust arresters are discussed.

A. F. A. Selects Chicago for 1931 Convention

Announcement has just been made by the American Foundrymen's Association that the 1931 annual meeting of the association will be held at the Stevens Hotel, Chicago, the week of May 4, 1931.

In preparation for the coming convention, the various subcommittees of the Program and Papers Committee all report that a full schedule of sessions, shop-operation courses and round-table luncheon meetings are being scheduled. In addition, the papers on new foundry developments promise one of the most interesting conventions ever held, for foundrymen in all branches of the industry.

To the shop-operation courses on steel, gray iron and non-ferrous shop practice held in the past, two more courses will be added in 1931—on malleable foundry practice and sand control. It has become evident that these courses, organized particularly for the purpose of giving practical instruction in shop practice fundamentals, fill a distinct need, and the schedule for 1931 will be arranged more carefully and thoroughly than ever before.

Personnels of the gray iron and malleable shop-operation committees already have been selected, and the non-ferrous, steel and sand control committees are being organized rapidly. Members of the malleable and gray iron groups are as follows:

Malleable

J. B. Deisher, *Chairman*, Columbia Malleable Castings Corp., Columbia, Pa.

August VanLantschoot, Iowa Malleable Iron Co., Fairfield, Iowa.

Walter Ranis, Union Malleable Iron Co., East Moline, Ill.

A. M. Fulton, Northern Malleable Iron Co., St. Paul.

Gray Iron

Max Kuniansky, *Chairman*, Lynchburg Foundry Co., Radford, Va.

C. J. Soullin, Alda Research Laboratories, St. Louis.

The general sessions and round-table luncheon meeting will complete the program which will start on Monday afternoon of convention week, continuing through Thursday.

Thermodynamics of Zinc Smelting

A comprehensive study of the thermodynamics of zinc smelting has been completed by the United States Bureau of Mines, Department of Commerce, at its Pacific Experiment Station, Berkeley, California, in coöperation with the University of California. The results have been published in Bulletin 324, "Zinc Smelting from a Chemical and Thermodynamic Viewpoint," by C. G. Maier, which may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 20 cents.

Errors in Molybdenum Analysis

Several cases in which widely divergent amounts of molybdenum were reported by different responsible customs laboratories, to which quartered portions of the same pulp samples had been sent for analysis, have recently been investigated by the Rare and Precious Metals Experiment Station of the United States Bureau of Mines, in coöperation with the University of Nevada, Reno, Nevada.

An oxidized lead ore which contained considerable vanadium and less than a percent of molybdenum was reported as containing molybdenum trioxide ranging from 3.14 to 0.24%. The high results were due to the noncomplete elimination of vanadium from the molybdenum.

A fine grained rock containing considerable graphite did not indicate clean residues by the usual acid decomposition. Several chemists used prolonged fusion with soda ash and nitre. The solutions contained phosphorus derived from the ore which was precipitated as lead phosphate and mistaken for the molybdate.

The elements most likely to cause trouble are vanadium, tungsten, uranium, arsenic, antimony, titanium, tin, phosphorus and chromium. The precautions necessary to eliminate these and other impurities vary with the type of ore and the method of analysis.

Notes on the determination of molybdenum with detailed analytical procedure is contained in Bureau of Mines Information Circular 6335.

Book Reviews

The Metallurgists' and Chemists' Handbook. By D. M. Liddell. McGraw-Hill Book Co., New York, Third edition, 1930. Cloth, 4 $^1/_2$ × 7 inches, 847 pages. Price $5.00.

In the revision of Liddell's useful handbook, he has, he states in the preface, attempted to include the metallurgical and chemical advances since the war. This resulted in a one-third increase in size, but at the same time, he attempted to keep the book as light in weight as possible, because he had in mind the "need of the engineer in the jungle."

The recognized value of the book has, of course, been increased by the revision. There is a vast amount of information in it. One can find, if he happens to want to know about them, the formula for the cissoid of Diocles, the explosibility of stinking smut from wheat, a note on the Kiss process, and that a meou (China) is 0.15182 acre and a candy (India) is 529 lbs.

Forty pages are given to Campbell's well-known list of alloys, from "accumulator metal" to "Ziskon," all of which is interesting historically, but the list contains so many out of date and useless alloys that one wonders why the jungle-dwelling engineer wasn't given a selected list of useful alloys instead.

Even though revision has been made, in many ways the data selected are far from representing up-to-date information. The reader will not get much modern data on such topics as endurance of metals, high temperature properties, or 18 and 8.

Nitriding and tungsten carbide are mentioned, but one would have a hard time to tell what their utility and their limitations are.

Such facts as that 60 Au 40 Pt melts at 1320° C. are given under pyrometry, but there is no discussion of pyrometry in general. Formulae for the thermal E. M. F. of thermocouples are given, but no tables. Specifications for shape of test specimens from sheet metal are found, but no details on ordinary test bars. Heat treatment of steel is dismissed by giving the definitions for heat-treating terms.

The wear of metals is dealt with by a statement indicating that the Derihon abrasion tester is the last word, and that the abrasion of grinding surfaces may be avoided by welding on a layer of stellite. We don't believe the former statement at all, and the second is only one of many methods for reduction of wear. Although the handbook is obviously meant for the mill man and the smelter metallurgist rather than the physical metallurgist, and there is comment on crushing and grinding machinery in general, no mention is made of austenitic manganese steel for crusher jaws; nor can we find anything about rubber linings for ball mills.

Many entries in the tables are irritating because they purport to tell something but don't. Data on tests of corrosion due to H_2S include "special Climax alloy steel," which means nothing to the reader.

Cohen's brain storm on allotrophy of metals is still accepted. It is stated that it is "apparent that α and β modifications exist in most of the metals" and a transition temperature of about 70.5° C. is given for Cu!

On page 164 the thermal conductivity, K, of air is given as 0.00057 on page 173 as 0.000055 with a footnote stating that some of these constants differ from those on the former page, but the difference is not serious!

Other misprints are fairly common, "cememtite," "magmalium," "tantulum," "$KeSO_4$" and at the top of page 663, "mass furnaces" for blast furnaces.

It would be ungracious to expect either 100% accuracy or 100% correct choice of material in a compilation of this sort, yet we are so used to finding what we want to know in Liddell that we are rather disappointed in finding that the new matter is hardly up to the standard set by the former editions. Nevertheless, it is still one of the most handy and indispensable sources of information.

We were particularly glad to see that revision had not eliminated the instructions which tell what to do in case of cyanide poisoning, i. e., apply various antidotes, and "then call the undertaker."—H. W. Gillett.

The Constitution of Steel and Cast Iron. F. T. Sisco. American Society for Steel Treating, 1930. Cloth, 6 × 9 inches, 332 pages. Price $3.00.

An educational treatment of the subject, previously appearing serially in the Transactions of the A. S. S. T., now published in book form.

This is a good introduction to ferrous metallography, especially suited for college students or for practical men who wish to get an understanding of general theories. Controversial matters, such as why martensite is hard, are touched upon, but not allowed to interrupt too much the account of indisputable facts.

A discussion of the structure and heat-treatment of carbon steel forms the bulk of the treatise. Cast iron is treated fairly fully, malleable, cold worked steels and alloy steels but briefly mentioned, wrought iron not at all.

Sauveur's text-book is quite freely drawn upon, as are other sources of information in English. The contributions of Germany and France to metallography seem to be somewhat overlooked.

Study of this book should put the student in shape to assimilate current articles on more detailed points of metallography. It is concise without being curt. The author states that he may have sacrificed accuracy for clearness, but in most cases where the reader might disagree with Sisco, he will have to admit that Sisco's interpretation is about as plausible as the one he himself might prefer.

On the whole, the book fulfills its educational purpose quite adequately. The subject can scarcely be so written up as to be "easy reading," but Sisco's book can be classed as fairly "easy studying."—H. W. Gillett.

The Oxy-acetylene Welder's Handbook. By M. S. Hendricks. Acetylene Journal Publishing Co., Chicago, 1929. Leather, 4 × 5 $^1/_2$ inches, 205 pages. Price $3.00.

The author as editor of the *Acetylene Journal* has undoubtedly become familiar with many of the requirements of the engineers for reliable welds and the short comings of those engaged in the art of welding. In a style which should appeal to the practical welder an endeavor is made to point out the most prevalent sources of trouble and means of overcoming many causes of poor welding.

The first two chapters one on "Welding Gases" and the other on "Welding Equipment" are abbreviated to such an extent as to be of questionable value but the third chapter on "Setting Up Equipment" is not open to this objection and should appeal strongly to not only the operators of oxy-acetylene equipment but to safety engineers who are responsible for the proper use of the equipment.

Various methods of welding are briefly described and this is followed by an excellent dissertation on the "Inspection of Welds" which every welder should carefully study.

The last chapter contains a short discussion of other methods of joining metals such as, brazing, soldering together, with a few remarks on hard facing and cutting.—John J. Crowe.

Index to Iron and Steel Patents. By V. E. Kinsey & T. E. Hopkins. American Compilation Co., Pittsburgh, 1930. Cloth, 6$^1/_4$ × 9$^1/_4$ inches, 356 pages. Price $25.00.

This work includes briefs of the U. S. patents on metallurgical methods of making iron and steel and their alloys. These run from No. 3065 of January 6, 1844, for making malleable iron direct from ore, to 1,768,710 of July 1, 1930, for utilization of chromium from converter slag. There are probably more than 1800 patents listed. The patent number, date, patentee's name, assignee, object of the invention, method used or analysis covered and the product dealt with, are given for each patent. Alloys containing 5% or more of iron are included.

The index includes the names of the patentees and the numbers of their patents, names of the assignees and numbers of patents assigned, a classification by types of iron and steel, one by constituents, a list of suggested uses and the corresponding patent numbers, and a list of the patent numbers according to the subclasses of the Patent Office.

While the briefs are, of course, so short that they serve only as an indication of the nature of the patent, the indexing is complete enough so that the use of the volume should often lead those interested in finding out what has been patented in a given line, to the desired information without the employment of a patent lawyer. While the price of the book is high, it corresponds to about a cent per patent briefed, and if it should serve to avoid a lawyer's services once in a reader's lifetime, it would be cheap at the price.

Index of Iron and Steel Patents should be of service to those who are forced to deal with patents in this field.

Yearly supplements are to follow.—H. W. Gillett.

Modern Dental Metallography. By O. E Harder. Burgess-Roseberry Co., Minneapolis, 1930. Mimeographed, 180 pages. 87 figs. Price $3.50.

This is a text-book designed especially for the use of students in the College of Dentistry of the University of Minnesota. The first 78 pages deal with general metallography in condensed, but adequate form. The balance deals directly with dental materials. Alloys of Ag, Sn, Cu and Zn which, with Hg, form amalgam fillings, and the factors affecting their utility as dental restorations, are next discussed.

Waxes used in dentistry, plaster and investments and their properties are described. Three chapters deal with gold foil, gold alloys, cast and wrought, their heat-treatment and with solders for and soldering of dental alloys.

"Cohesive" gold, foil free from tightly-absorbed gas films, which will weld under pressure at mouth temperature, is interestingly discussed. The precious metal alloys, their properties and the methods of testing are described.

The dental industry uses some 7% of the total platinum used, half as much as the chemical industry, and 40% of the palladium.

Type compositions for solders for gold alloys of varying fineness are outlined, and precautions to be used in soldering are discussed.

The final chapter deals with "technic" or practice alloys and special alloys not used in finished dental restorations.

Each chapter has a selected bibliography. Considerable attention is given to the data secured by Souder, Coleman and Taylor in work at the Bureau of Standards.

Other pertinent data are included from the literature, as well as considerable hitherto unpublished data secured at the University of Minnesota.

The book will be of service not only to members of the dental profession but to metallurgists interested in amalgam and precious metals from other points of view. The mimeographing is well done though the reader will not find it as easy to read as if the book were printed. Micrographs are printed on a suitable grade of paper, and the illustrations are quite adequate.

"Metallography" is taken as synonomous with physical metallurgy, and the scope of the work is larger than the title would indicate.—H. W. Gillett.

Text-book of the Materials of Engineering. By Herbert F. Moore. McGraw-Hill Book Co., New York, Fourth edition, 1930. Cloth, 6 × 9 $^1/_2$ inches, 409 pages. Price $4.00.

In common with other texts of this kind, the major portion of this book is devoted to the presentation of facts and figures concerning the recognized properties of the common materials of engineering and construction. It is sufficiently comprehensive in its scope to furnish a solid foundation for the student of engineering or for the individual who is called upon to make use of such materials. In addition the student will find the appended list of significant questions a great assistance in the mastery of this subject. The elimination of all save the most essential details in the processes of manufacture, certainly enhances the value of the book to all except the specialist. For those who wish to specialize or who desire more detailed information on specific matters, the excellent bibliographies following the separate chapters afford fertile fields for further study.

Considerable care has been exercised to differentiate between the terms "elastic limit," "limit of proportionality" and "yield point." Following this fundamental conception appear valuable chapters on "elastic failure," "failure by creep" and "fatigue failure." In the last mentioned section the author very justifiably writes as an authority.

The chapter dealing with the interrelations between crystalline structure and other physical properties, written by Prof. J. O. Draffin, most readably and comprehensively handles a subject which might easily become confusingly complex.

The discussion of cementing materials has been reduced to a minimum, highly commendable except in the case of Portland cement. Here, in contrast with most texts, the author has completely omitted the characteristics and standard requirements of this very widely used material. The material "concrete" has, however, been very fully treated in the chapter by Mr. H. F. Gonnerman. As would be expected this section outlines very fully the methods of proportioning concrete with special emphasis on the "cement-water ratio" and "bulking" of sand.

The section devoted to testing is written wholly without predjudice as regard to testing machines. It appears a bit weak along the line of measuring instruments and strainometers since several of the best types have been completely omitted.

The closing chapter of the book presents some very valuable material generally ignored by writers on this subject. The well-chosen excerpts from the Standards of the A. S. T. M. should furnish the student with a solid background for the interpretation of specifications which he may expect to meet in his future practice.—Irving H. Cowdrey.

Der Spritzguss und seine Anwendung. Beuth-Verlag, Berlin, Second edition, 1930. Paper, 6 × 8 ½ inches, 48 pages.

This booklet was compiled by the Reichskuratorium für Wirtschaftlichkeit as a descriptive review of the die casting process as developed and used in Germany. It is divided into four sections which cover in turn a general description of the process and machines, a discussion of the alloys used, some comments on the proper design of parts to be die cast and an elaborate study of the economy of the die casting method.

It is interesting to note, in the first section, that the German die casters have restricted the term die casting to the process of forcing metal under pressure into permanent metallic molds.

The description of the process and the drawings of typical machines are reminiscent of American practice throughout. The suggestion is made that the use of hand-operated machines is increasing.

The section on alloys considers the three prominent groups—the tin-lead base, the zinc base and the aluminum base alloys. Comment is made on the development of methods for casting brass and electron metal.

The reviewer does not feel competent to discuss the tin-lead, and aluminum base alloys. In the case of the zinc base alloys many points of divergence, from our own conceptions, will be found as well as many points of agreement. For example, in agreement with information developed recently in this country, it is pointed out that aluminum should not be present in excess of 0.5% if large amounts of tin are to be present.

In strong contrast with the recent developments in American practice, it is stated that lead may be present up to 1% without deleterious effect. This is particularly interesting in view of the present trend toward zinc of very high purity in this country.

A list of 11 zinc base alloys is given of which two compare closely with the familiar 6% tin and 4–3 alloys in use here. No mention is made of the addition of magnesium which has come into wide use in recent years in America.

The section on the design of parts to be die cast adds nothing to the information available in our own literature. The final chapter, on costs, will probably be of more interest than value to the American die caster.

The booklet as a whole is an adequate résumé of German practice and should be of interest to the die casters of this country.—E. A. Anderson.

National Physical Laboratory Report for 1929. His Majesty's Stationery Office, London, 1930. Paper, 8 × 10½ inches, 298 pages. Price 11 sh.

The report on the department of metallurgy and metallurgical chemistry appears on pages 250 to 277, and covers the following: Physical structure of metals and alloys, Behavior of metals and alloys under strain and heat generated by plastic deformation, Preparation of single crystals, Preparation of pure metals, Dilatometric study of alloys, Surface tension of liquid metals, Light alloys, Minor metals: beryllium, cadmium and titanium, Alloys for use at high temperatures, Gases in steel, Cracking of boiler plates, Alloys of iron research: Iron-silicon alloys and iron-chromium alloys, Dental alloys and amalgams, Impurities in copper and Die casting of aluminum alloys.—R. R.

Aluminothermie. By Dr. Karl Goldschmidt. Verlag S. Hirzel, Leipzig, 1925. Paper, 6 × 9 inches, 174 pages. Price 12 RM.

The value of this book lies less in its practical information on thermal reaction phenomena than in its exhaustive treatment of the history and development of this important field of modern metallurgy and of aluminum especially. Written in 1925 the part on practical application is to some extent superseded and of no great value but the fundamental facts and the theoretical explanations of the aluminothermic reaction are treated so clearly and simply and the whole book is written so interestingly that it will always keep its place as a source of information for the application of aluminothermic metallurgical processes for the production of metals and alloys free of carbon and difficult to melt, also for the aluminothermic welding. Principally, the production of chromium, ferro-chrome, manganese, ferro-vanadium, ferro-titanium, ferro-boron, molybdenum alloys and some other metals are discussed. A chapter is also devoted to other metals as aluminum with which aluminothermic reactions can be obtained. Especially treated is the aluminothermic welding process but the more recent developments make this chapter less useful; the great number of illustrations, however, are very instructive for practical application.—
M. Hartenheim.

Einführung in die Metallographie. By E. Vollhardt. Verlag von Bonness & Hachfeld, Potsdam & Leipzig, 1930. Paper, Part 1, pages 1–32, Part 2, pages 33–52. Price 2 RM.

This is a very brief correspondence school course in metallography for home study. Each chapter is followed by a series of questions and answers.

There seems to be no arrangement for sending in specimens and micrographs for criticism as was done in Sauveur and Boylston's correspondence course, and it is a question whether either one's technique or his understanding of theory would be greatly advanced by use of the pamphlets. The treatment is too brief to help materially on the latter.

Metallographers who understand the contents of the pamphlets might use it for another purpose, home study of German, since the brevity of the treatment leads to the use of sentences which are shorter than is the case with average technical German. Unfortunately for this purpose, German type which is almost out of use in technical publications, is used in this.—H. W. G.

Die elektrischen Schweissverfahren. By Hch. Krökel & Hans Niese. Walter de Gruyter & Co., Berlin-Leipzig, 1930. Cloth, 4½ × 6¼ inches. 136 pages. Price 1.80 RM.

The popular Göschen Collection is enriched by the new Volume No. 1020, available at the popular price of some 43 cents. Electric welding in industry gained considerably in importance during the last years and the task seems to be justified to briefly collect all information on the subject.

The authors tackled this work more from a practical view point so that the publication not only represents a useful pocket size book for students and engineers but also instructive reading for the man in the shop, particularly for the welder.

After outlining resistance and arc welding in the first 2 chapters, the authors discuss in detail the electric welding facilities, i. e. arc welding machines self excited and externally excited, transformers and auxiliary equipment. The next chapters deal with the technique of arc welding, automatic electric welding machines, welding of cast iron, training of electric welders, testing methods, economy and 2 practical applications in ship building.

The metallurgical part of the problem is only briefly mentioned and will certainly be more up-to-date in the revised second edition in which any improved reproduction of the illustrations especially on the last pages, would also be appreciated.—E. Fetz

Gmelin's Handbuch der anorganischen Chemie. 8th edition Eisen. Verlag Chemie, Berlin, 1930. Paper, 6¾ × 10 inches. Part B 2, pages 313–512. Price 32 RM. Part B 3, pages 513–656. Price 24 RM.

In reviewing the first 3 parts of the volume on iron in the June issue of Metals & Alloys it was pointed out what an excellent piece of work would be accomplished by the new publication of Gmelin's handbook. Two more parts have been published meanwhile, continuing the compounds of iron.

Part B 2 and B 3 continue iron-chlorine from part B1 and deal with iron-bromine, iron-sulphur, iron-selenium, iron-tellurium, iron-boron, iron-carbon. The iron carbides are omitted in this part but are going to be considered in one of the divisions of Part A, which will cover the metallurgy of iron.—G. Neuendorff.

Ergebnisse der Technischen Röntgenkunde. I. Die Röntgentechnik in der Materialprüfung. By 19 authors. Akademische Verlagsgesellschaft, m. b. H., 1930. Cloth, 6 × 9 inches, 206 pages. Price 16.80 RM.

This little book, the first of what should prove to be a very interesting and valuable series, presents in excellent fashion a cross section view of X-ray science as applied to the testing of materials at the present time. The list of the authors for each of the chapters in this symposium contains some of the best known authorities in the field. The subject matter is as follows: William Conrad Roentgen and the Technic, by Riebensahm; Introduction, by Guertler; Elementary Physics of X-rays, by Hengstenberg; High Voltage Apparatus, by Behnken; X-ray Vacuum Technic, by Seemann; The Development of X-ray Tubes, by Franke; Photography and Technical X-ray Science, by Eggert; Chemical Action of X-rays, by Gunther; The Method of Determination of Fine Structure of Materials, by Schiebold; Methods of Interpretation of X-ray Diagrams, by Herrmann; X-rays in the Service of Metallurgy, by Sachs; The Detection of Crystal Class by Means of X-rays, by Von Göler; The Application of X-rays in Technical Chemistry, by Mark; Chemical Analysis with X-ray Spectra, by Stintzing; The Fundamentals of Penetrating Illumination of Materials by X-rays, by von Schwarz; The Application of X-rays and Welding Technic, by Kantner; X-rays as a Modern Testing Method in Construction and Completed Erection, by Herr; Possibilities of New Diascopic Testing of Production in Foundry Practice, by Reininger; Conclusion, by Bock.

This entire collection is designed to arouse interest in the possibilities of new X-ray methods. Its appeal, therefore, is to the industrial executive or research director who is throughly alive to scientific developments. The book serves as a splendid introduction to the more extended treatises which are designed for those who undertake actual X-ray research. Each chapter is well illustrated and contains numerous references to original work. The symposium forms an excellent addition to any library and the further members of the series will be awaited with greatest interest.—G. L. Clark.

Die thermoelektrische Temperatur- und Wärmeflussmessung, E. Raisch & K. Schropp. Forschungsheim für Wärmeschütz. Munich, 1930. Paper, 6½ × 9½ inches, 93 pages. Price 6 RM.

The first part of the book covers the thermoelectric measurement of temperature. The authors point out in the preface that this subject has been covered in a number of treatises but include it here because the second part of the book, covering the thermoelectric heat flow measurement, is built up on the former and the two measuring methods are closely allied.

In the second part, the theoretical considerations, the requirements to be met by heat flow meters as well as their application, are covered. The development of the heat flow meter is covered. Information on the performance of the tests is also given.—R. Rimbach.

Kühlen und Schmieren bei der Metallbearbeitung. K. Gottwein. (Technische Hochschule, Breslau). V. D. I. Verlag, Berlin, 2d Ed. 1928. Paper, 6 × 8½ inches, 93 pages. Price 6 R.M.

Cutting oils and coolants and their use in various machining operations on various metals are concisely discussed. A few paragraphs are devoted to lubricants for deep-drawing, wire and rod drawing, and hot and cold rolling. So many points are covered that the discussion of each is brief.

The pamphlet does not discuss very deeply the physical properties required in such lubricants, and does not take up any metallurgical points about the materials to be cut or the tools used. It is written primarily to indicate to the machine shop the general type of lubricant or coolant desirable for a given service.

The recommendations are summarized in a table.—H. W. Gillett.

Grundlagen der Technischen Röntgendurchstrahlung. By Rudolf Berthold. Barth, Leipzig, 1930. Cloth, 5½ × 8½ inches, 109 pages. Price 10.80 RM.

This little book is the first in the field of the fundamentals of radiography, the science which is concerned with determination of gross structure. The usual idea is that very little science is involved in making shadow photographs for medical diagnosis or for the testing of steel castings and other materials. This treatise demonstrates the fact that the science is a very exact one and that best results can be obtained only by the application of a scientifically grounded technic. First in the monograph is presented fundamental material on the X-rays themselves as regards the influence of voltage, current, distance of the focal spot of the X-ray tube, influence of the kind and thickness of the X-ray tube glass, and similar material. In chapter two are treated the fundamental laws of absorption which, of course, are involved in the diminution in intensity of X-rays in passing through matter. Succeeding topics are as follows: the photographic layer without intensifying screen and with intensifying screen, the fluorescent screen, physiological fundamentals, detailed presentation of correct technic as regards illumination in milliampere seconds as the function of thickness of various material such as aluminum, iron, copper, etc.; all of the factors involved in the detection of imperfections or inhomogeneities in various types of metal specimens, approved apparatus including high tension equipment, X-ray tubes, auxiliary equipment, cost of equipment, etc. The author is well qualified by years of research in the development of equipment and in actual industrial radiographic research to present this book for all industrial laboratories such as those in metallurgy in which radiographic research and testing has become or will become a part; and indeed for men engaged in medical diagnosis by X-rays this little book is indispensable because it covers in excellent fashion a unique field. Some of the material, of course, is designed particularly for German application but this in no wise detracts from the usefulness of it in this country.—
G. L. Clark.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates an Engineering Information Service, we are able to publish every month a list of important patents from the United States, Canada, England, Germany, France, Switzerland, Denmark, Holland, Sweden, Norway and Italy. Photostatic copies of patents and translations will be supplied at reasonable rates. Patent searches made at minimum rates. Estimates cheerfully given. Readers who wish information about this service may secure it by writing to the Patent Department, METALS & ALLOYS, *810 Eighteenth Street, Washington, D. C.*

United States Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Chaplet. E. Sonnet. No. 1,775,874. Oct. 19, 1929; in Germany Aug. 28, 1929.

Blast furnace. R. Franchot and K. P. McElroy, assignors to Ferro Chemicals, Inc. No. 1,775,955. Aug. 6, 1928.

Apparatus for the manufacture of castings of difficultly-meltable metals and metalloids. H. Voigtländer and O. Kaufels, assignors to Gewerkschaft Wallram Abteilung Metallwerke. No. 1,776,053. June 20, 1929. Originally filed Aug. 25, 1925; in Germany Sept. 8, 1924.

Means and method for forming soft-metal bars. B. F. Burt. No. 1,776,103. Feb. 7, 1929.

Apparatus for heat treating. R. M. Heames *et al.* No. 1,776,117. June 2, 1927.

Melting pot. A. N. Otis, assignor to General Electric Co. No. 1,776,128. Mar. 5, 1927.

Cushioning device for presses. F. J. Rode, assignor to Marquette Tool & Mfg. Co. No. 1,776,271. Jan. 30, 1929.

Electrical apparatus. (Zn-Ag contact.) H. M. Williams, assignor to Frigidaire Corp. No. 1,776,276. Apr. 3, 1928.

Die holder for wire-drawing benches. C. Siegfried, assignor to Les Frères Bréguet. No. 1,776,296. Mar. 13, 1929; in Switzerland Dec. 15, 1928.

Mold for casting metals. W. F. Eppensteiner, assignor to The American Metal Co. No. 1,776,355. Mar. 7, 1929.

Process of making bimetallic strips, plates, or the like. F. W. Miller *et al.* No. 1,776,364. Nov. 11, 1927; in Great Britain Nov. 26, 1926.

Rolling mill. L. Iversen, assignor to Mesta Machine Co. No. 1,776,436. July 10, 1926.

Rotary casting apparatus. F. G. Carrington, assignor to Ferric Engineering Co. No. 1,776,540. Feb. 24, 1927.

Container for rotary casting apparatus. Same patentee and assignee. No. 1,776,541. Mar. 3, 1927.

Cooling system. Same patentee and assignee. No. 1,776,542. Mar. 3, 1927. No. 1,776,543. Mar. 23, 1927. No. 1,776,546. May 11, 1927.

Casting ladle. Same patentee and assignee. No. 1,776,544. May 4, 1927.

Apparatus for cooling molds. Same patentee and assignee. No. 1,776,545. May 10, 1927.

Pipe-extracting apparatus. Same patentee and assignee. No. 1,776,547. July 6, 1927.

Trough. Same patentee and assignee. No. 1,776,548. Oct. 26, 1927.

Welding machine and method. H. S. Holmes and L. H. Hoffer, assignors to Metropolitan Engineering Co. No. 1,776,587. Sept. 10, 1924.

Molding apparatus. A. T. Bateman and A. Irvine, assignors to Bohn Aluminum & Brass Corp. No. 1,777,287. Aug. 17, 1928.

Mold stand. A. T. Bateman and F. E. Storey, assignors to Bohn Aluminum & Brass Corp. No. 1,777,288. Aug. 27, 1928; No. 1,777,289. Feb. 25, 1929.

Feathery copper powder and process of producing the same. W. Koehler, assignor to The Koehler Chemical Co. No. 1,777,371. Jan. 22, 1930.

Sintering machine and the like. E. Cuddihy. No. 1,777,398. June 5, 1928.

Mechanism for casting annealing-box covers. H. E. Sheldon. No. 1,777,506. Mar. 8, 1929.

Annealing box. M. P. Wilson. No. 1,777,595. July 14, 1928.

Process and apparatus for refining industrial metals in the molten state. J. A. Jack. No. 1,777,617. Mar. 31, 1928; in Great Britain Mar. 6, 1928.

Method of forming ingots for working. T. D. Stay and W. Holzhauer, assignors to Aluminum Company of America. No. 1,777,657. Feb. 11, 1929.

Welder's helmet. W. Shirmer, assignor of one-half to W. L. Allison. No. 1,777,454. Dec. 26, 1928.

Welding process. R. Peterson. No. 1,777,531. Aug. 26, 1927.

Method of forming magnesium ingots for working. T. D. Stay and W. Holzhauer, assignors to American Magnesium Corp. No. 1,777,658. June 4, 1929.

Method of forming zinc ingots for working. T. D. Stay and W. Holzhauer. No. 1,777,659. June 4, 1929.

Car-wheel manufacture. J. P. Kittredge. No. 1,777,673. Nov. 3, 1927.

Method of making molds. W. Klepsch. No. 1,777,975. Sept. 15, 1927; in Czechoslovakia and Germany June 29, 1926.

Annealing apparatus. L. L. Lewis, assignor to Blair Strip Steel Co. No. 1,777,978. Dec. 2, 1929.

Method of and flask for facilitating solidification of metal centrifugally cast against a refractory lining. A. Losey, assignor to Sand Spun Patents Corp. No. 1,777,979. Mar. 1927.

Reduction of ores, oxides and the like. H. E. Coley. No. 1,777,993. Nov. 2, 1923; in Great Britain Nov. 10, 1922.

Core for metallic castings and method of making the same. H. M. Dent and F. W. Less. Assignors to General Plastics, Inc. No. 1,777,998. May 22, 1929.

Process for and relating to the separation of gold, silver and lead from crude antimonial metal. S. G. Blaylock *et al.*, assignors to The Consolidated Mining and Smelting Company of Canada. Nos. 1,778,017 and 1,778,018. May 3, 1929; in Canada May 21, 1928.

Process for and relating to recovering of gold, silver and lead from roasted or oxidized antimonial ores, antimonial flue dusts and antimonial by-products. S. G. Blaylock *et al.*, assignors to The Consolidated Mining and Smelting Company of Canada. Nos. 1,778,019 and 1,778,020. May 3, 1929; in Canada May 21, 1928.

Heat-treating furnace. C. W. Spicer. No. 1,778,045. Apr. 21, 1928.

Process of and apparatus for expanding blanks by rolling. F. Kocks. No. 1,778,111. Mar. 1, 1929; in Germany Mar. 31, 1928.

Alloy steel. (Cr-W-V steel.) J. A. Nelson, assignor to Barber-Colman Co. No. 1,778,226. Sept. 14, 1925.

Cushioning device for sheet-metal presses. F. J. Rode, assignor to Marquette Tool & Mfg. Co. No. 1,778,229. May 25, 1929.

Process of refining bismuth. T. H. Donahue, assignor of one-half to Cerro de Pasco Copper Corp. No. 1,778,292. July 8, 1929.

Header for ingot molds. A. Forrest, assignor, by mesne assignments, to Republic Steel Corp. No. 1,778,316. Dec. 12, 1927.

Core and composition for producing the same. F. B. Mason, assignor to Swan-Finch Oil Corp. No. 1,778,329. Feb. 15, 1929.

Drawing press. R. W. Glasner. No. 1,778,358. July 18, 1930.

Coating for welding electrodes. R. E. Kinkead, assignor to Hollup Corp. No. 1,778,392. Dec. 13, 1928.

Winding for electric furnaces. E. F. Northrup, assignor to Ajax Electrothermic Corp. No. 1,778,398. June 5, 1928.

Furnace for roasting sulphide and other ores. E. Bracq. No. 1,778,415. Feb. 11, 1926; in France Mar. 9, 1925.

Apparatus for forming oval structural high-carbon-steel tubes. F. P. Vincent. assignor to Steel and Tubes, Inc. No. 1,778,438. June 23, 1924, (Original filed Aug. 18, 1922.)

Metal-rolling process and apparatus. A. R. Earnest. No. 1,778,487. Oct. 3, 1928.

Apparatus for making molds. O. J. Kuhlke, assignor to National Rubber Machinery Co. No. 1,778,500. Apr. 27, 1929.

Open-hearth furnace. S. Naismith. No. 1,778,505. July 31, 1926.

Cupola furnace and method of operating the same. V. S. Durbin. No. 1,778,524. Feb. 11, 1929.

Electric refining furnace. T. F. Bailey. No. 1,778,578. Jan. 28, 1928.

Molding machine. R. F. Ringle. No. 1,778,609. Dec. 5, 1927.

Treatment of metals with acid liquors. M. Hartmann and W. Klarer, assignors to the Firm: Society of Chemical Industry in Basle. No. 1,778,-634. June 4, 1929; in Switzerland June 7, 1928.

Casting machine. G. L. Wilson. No. 1,778,652. May 31, 1928.

Manufacture of resistor rods with thickened portions. G. Egly, assignor to Gebrüder Siemens & Co. No. 1,778,665. Dec. 31, 1926; in Germany Apr. 10, 1926.

Electrode (Cu-Ni-Si). T. S. Fuller, assignor to General Electric Co. No. 1,778,668. June 30, 1927.

Furnace roof. E. P. Stevens, assignor to American Arch Co. No. 1,778,776. Dec. 21, 1922.

Annealing box. H. A. Fisher. No. 1,778,798. Apr. 30, 1929.

Method of forming electric heater plates. L. McKinney, assignor to The Griswold Manufacturing Co. No. 1,778,808. Dec. 11, 1928. (Original May 9, 1928.)

Stirring or poking apparatus for electric furnaces. P. L. J. Miguet, assignor to Soc. Electrométallurgique de Montricher. No. 1,778,809. Oct. 29, 1928; in France Feb. 7, 1928.

Apparatus for the roasting or sintering of ores and the like. G. E. Storer, assignor to National Processes Ltd. No. 1,778,872. Jan. 18, 1929; in Great Britain July 21, 1928.

Arc-welding. R. E. Frickey and A. S. Kalenborn, assignors to Welding Service, Inc. No. 1,778,973. Jan. 31, 1930.

Purification of zinc solutions. R. H. Stevens, *et al.*, assignors to The Rhodesia Broken Hill Development Co. Ltd. No. 1,778,987. Aug. 25, 1927; in Southern Rhodesia Aug. 13, 1926.

Apparatus for the production of section iron with box-shaped cross sections. J. Meiser and W. Köhler. No. 1,779,185. Aug. 4, 1927; in Germany Aug. 14, 1926.

Molding machine. G. Furman, assignor to The Beardsley & Piper Co. No. 1,779,230. Oct. 19, 1928.

Process for recovering arsenic, antimony and tin from mixtures of their salts. C. A. Heberlein, assignor to American Smelting and Refining Co. No. 1,779,272. May 21, 1926.

Process of electric welding. G. Kalschne, assignor to General Electric Co. No. 1,779,278. Sept. 15, 1927; in Germany Sept. 30, 1926.

Portable welding machine. E. J. von Henke, assignor to American Electric Fusion Corp. No. 1,779,365. Oct. 8, 1927.

Spelter-removing apparatus. R. R. Bloss, *et al.*, assignors to The International Derrick & Equipment Co. No. 1,779,366. June 5, 1926.

Steel alloy. (Mo-V steel.) L. M. Brown. Reissue No. 17,846. (Original No. 1,643,054 filed Feb. 14, 1927.) Oct. 31, 1928.

Reduction of ores. F. L. Duffield. No. 1,779,411. Sept. 21, 1928; in Great Britain Oct. 10, 1927.

Metal-heating furnace. R. Kaier, assignor to The Singer Mfg. Co. No. 1,779,435. Aug. 3, 1927.

Process of electrodepositing metals of the platinum group. C. W. Keitel, assignor to Baker & Co., Inc. No. 1,779,436. July 2, 1929.

Electrodeposition of platinum metals. H. E. Zschiegner, assignor to Baker & Co., Inc. No. 1,779,457. Oct. 7, 1927.

Core-bar gauge. I. Langston, assignor to McWane Cast Iron Pipe Co. No. 1,779,477. Sept. 2, 1927.

Method of working metal rods, bars and the like. J. T. Leech, assignor to Union Drawn Steel Co. Nos. 1,779,478 and 1,779,479. Feb. 19, 1929.

Apparatus for handling cores. J. R. McWane, assignor to McWane Cast Iron Pipe Co. No. 1,779,484. Feb. 28, 1928.

Core-making apparatus. Same patentee and assignee. No. 1,779,485. Mar. 6, 1928.

Plate casting and finishing machine. H. A. W. W. Wood, assignor to Wood Newspaper Machinery Corp. No. 1,779,523. Jan. 28, 1927, renewed Sept. 25, 1929.

Zinc-base die-casting alloy. E. A. Anderson, assignor to The New Jersey Zinc Co. No. 1,779,525. June 5, 1929.

Method of casting and rolling copper. W. F. Eppensteiner and H. M. Green, assignors to The American Metal Co. (Ltd.). No. 1,779,534. Feb. 13, 1928.

Process of welding. C. T. Siebs and T. A. Daniel, assignors to Western Electric Co., Inc. No. 1,779,563. July 31, 1926.

Alloy for electrical contacts. (Pd-Cu). E. F. Kingsbury, assignor to Western Electric Co., Inc. No. 1,779,602. May 16, 1924.

Alloy for electrical contacts. (Pd-W group metal.) Same patentee and assignee. No. 1,779,603. Mar. 2, 1926.

Method of and apparatus for heat treating magnetizable materials. H. C. Knerr. No. 1,779,604. Apr. 21, 1921, renewed Mar. 11, 1930.

Method of forming metal bodies. R. A. Lewis and J. M. Sylvester, assignors to Bethlehem Steel Co. No. 1,779,607. Apr. 11, 1927.

Metallurgical fuel and process for making the same. (*Method of transforming cast iron into steel.*) G. Jakova-Merturi, assignor to Soc. la Carbonisation, Soc. Générale d'Exploitation des Carbones. No. 1,779,744. Apr. 4, 1928; in France Apr. 11, 1927.

Apparatus for and method of forming castings. H. C. Carter and H. E. Spieth, assignors to Iron Fireman Mfg. Co. No. 1,779,763. Apr. 23, 1929.

Lead alloy, particularly for cable sheathings. M. Thielers. No. 1,779,784. Mar. 15, 1928; in Sweden Mar. 18, 1926.

Cleaning and preservation of metallic surfaces. J. C. Vignos, assignor to The Rubber Service Laboratories Co. No. 1,779,787. Aug. 2, 1928.

Tarnish-resisting silver and silver plate and process for producing the same. D. Gray, *et al.*, assignors to Oneida Community, Ltd. No. 1,779,809. Nov. 5, 1923.

Process of separating metallic compounds. (*Roasting and selective reduction of ores.*) O. A. Fischer. No. 1,779,841. July 13, 1926.

Process for coating with metal, porcelain, celluloid, etc., in a plastic state. J. Murer. No. 1,779,850. June 17, 1926; in Germany June 19, 1925.

Recovery of vanadium from ores and compounds. B. D. Saklatwalla, assignor to Vanadium Corp. of America. No. 1,779,856. Oct. 29, 1927.

Treatment of zinciferous materials containing lead and ore cadmium. L. E. Teter, assignor to The New Jersey Zinc Co. No. 1,779,862. Sept. 22, 1928.

Galvanizing-rack centrifuge. C. A. Giblin, assignor to Henry B. Newhall Corp. No. 1,779,934. Aug. 15, 1928.

Protective compound. Inhibitor for pickling baths. L. J. Christmann, assignor to American Cyanamid Co. No. 1,779,961. Sept. 18, 1929.

Furnace for and process of heating articles. H. A. Dreffein, assignor to Flinn & Dreffein Co. No. 1,779,964. Dec. 19, 1927.

Method of refining zinc. F. R. Kemmer, assignor to American Cyanamid Co. No. 1,779,973. May 2, 1928.

Extraction of tin from ores or materials containing tin. E. A. Ashcroft. No. 1,780,106. May 5, 1928; in Great Britain July 7, 1927.

Refractory material and process for its manufacture. J. I. Bronn. No. 1,780,114. Feb. 28, 1928; in Germany July 15, 1926.

Tunnel kiln. A. M. Duckham. No. 1,780,119. July 16, 1928; in Great Britain Aug. 12, 1927.

Method of and apparatus for repairing heated structures such as furnaces, retorts or the like. A. M. Duckham. No. 1,780,120. May 15, 1929; in Great Britain May 24, 1928.

Austrian Patents

Subject of Invention, Patentee, Patent No. and Date of Beginning of Term of Patent.

Automatic control for rollways with electrically driven rollers. F. Krupp A.-G. Friedrich Alfred-Hütte. No. 119,458. May 15, 1930.

Process for the direct introduction of throat dust or of ores in blowable condition into blast furnaces or other shaft furnaces. Vereinigte Stahlwerke A.-G. No. 119,460. May 15, 1930.

Tuyère for blast furnaces. Gutehoffnungshütte Oberhausen A.-G. No. 119,466. May 15, 1930.

Means for accelerating the annealing process in wire-annealing furnaces. A. G. Brown, Boveri & Cie. No. 119,464. May 15, 1930.

Gas-tight current connection for bright-annealing furnaces. A. G. Brown, Boveri & Cie. No. 119,467. May 15, 1930.

Hardening liquid for steel. O. Kroning and R. Boes. No. 119,736. May 15, 1930.

Machine for filling molds with sand or the like. W. Kurze. No. 119,725. May 15, 1930.

Chill mold for casting non-ferrous metals. M. Erichsen. No. 119,520. May 15, 1930.

Machine for casting light metals, such as aluminum and its alloys. Vereinigte Aluminum Werke A.-G. No. 119,537. May 15, 1930.

Copper-zinc alloys. Allgemeine Deutsches Metallwerk G.m.b.H. No. 119,761. Oct. 15, 1927.

Apparatus for the electroproduction of light metals, particularly magnesium and calcium. A. C. Jessup. No. 119,465. May 15, 1930.

Electrode for refining and alloying with metal baths. E. Bornand and H. A. Schlaepfer. No. 119,470. May 15, 1930.

High-frequency induction furnace. Oesterreichische Siemens Schuckert Werke, assignee of W. Esmarch. No. 119,737. May 15, 1930.

Process for forming a hard sliding surface in light metal cylinders for internal combustion motors. J. von Bosse. No. 119,469. May 15, 1930.

Adjustable backing device for the straightening rolls of sheet straightening machines. F. Ungerer. No. 119,732. May 15, 1930.

Process and device for increasing the energy of and for the formation of pointed flames in the electric arc. Presslicht Patent Verwertungsges. m.b.H. No. 119,328. May 15, 1930.

Welding head for electric arc welding with metallic wire. "Elin" A.-G. für elektrische Industrie. No. 119,451. May 15, 1930.

Process and machine for changing the shape of metallic bodies of substantially cylindrical shape. United States Cast Iron Pipe & Foundry Co. No. 119,453. May 15, 1930.

Charging device for shaft furnaces. E. Kröningen and K. Wolsky. No. 119,631. May 15, 1930.

Process for producing highly fire-resistant fused materials, chiefly composed of magnesium and aluminum oxides. T. R. Haglund. No. 119,509. May 15, 1930.

Process for the electrolytic production of protective layers of lead peroxide on electric conductors connected as anode. Siemens & Halske A.-G., assignee of W. Birett and J. Fischer. No. 119,775. May 15, 1930.

Process and furnace for the direct production of iron from its ores. A. Langer. No. 119,938. June 15, 1930.

Melting and refining cupola. P. Marx. No. 120,137. June 15, 1930.

Hearth furnace. Open Hearth Combustion Co. No. 120,159. June 15, 1930.

Process for making hollow castings in permanent molds. B. Fassl. No. 119,999. June 15, 1930.

Process for making sand castings of magnesium and magnesium alloys· I. G. Farbenindustrie A.-G. No. 120,002. June 15, 1930.

Cementation process, involving two solid phases. E. Feuer. No. 119,939. June 15, 1930.

Arch made of blocks having specially shaped outer faces, particularly for metallurgical furnces. W. Alberts. No. 119,952. June 15, 1930.

Aluminum alloy which is resistant to corrosion and to sea water. Vereinigte Aluminum Werke A.-G. No. 119,930. June 15, 1930.

Sulfuric acid-resistant soft lead. I. G. Farbenindustrie A.-G. No. 119,955. June 15, 1930.

Process for making aluminum-silicon alloys. Vereinigte Aluminum Werke A.-G. No. 119,933. June 15, 1930.

Partition for separation of the products in the fusion electrolysis of chlorides, particularly that of magnesium. I. G. Farbenindustrie A.-G. No. 119,943. June 15, 1930.

Holder for electric furnace electrodes. Siemens-Planiawerke A.-G. für Kohlefabrikate. No. 119,945. June 15, 1930.

Process for zinc-coating aluminum and its alloys. B. Jirotka. No. 119,937. June 15, 1930.

British Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

NOTE: Names of communicators, if any, are given in parentheses after the name of applicant. When the date applied for differs from the date on which the application was lodged at the British Patent Office, the former date is followed by *.

Welding-machine. Budd Wheel Co. No. 309,196. Apr. 6, 1928.*

Furnaces and or apparatus for the annealing or heat-treatment of metal and other goods. A. Smallwood and J. Fallon. No. 334,965. Apr. 25, 1929.

Parting compounds for foundry molds. A. E. White (Kelly Graphite Mills, Inc.). No. 334,857. June 5, 1929.

Electric arc carbons or electrodes. Cie. Lorraine de Charbons pour l'Electricité. No. 316,130. July 23, 1928.*

Methods for preventing the formation of deposits or incrustations in rotary tubular furnaces. F. Krupp Grusonwerk A.-G. No. 334,868. Apr. 20, 1929.*

Cupola furnaces. L. A. Bentley. No. 334,917. June 12, 1929.

Tunnel kilns. Woodall-Duckham Ltd., Doulton & Co., Ltd., and C. Bailey. No. 334,951. June 14, 1929.

Method for changing the form and improving the texture of hollow metal bodies. United States Cast Iron Pipe & Foundry Co. No. 334,960. Dec. 29, 1928.*

Manufacture and production of metal carbonyls. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 334,976. June 24, 1929.

Method and apparatus for the electrolytic treatment of metals. W. Gusseff. No. 335,003. July 24, 1929.

Working manganese iron or steel alloys. H. Wade (Taylor-Wharton Iron & Steel Co). No. 335,076. Oct. 4, 1929.

Manufacture of alloys. J. Gray (A. Pacz). No. 335,081. Oct. 7, 1929.

Aluminum alloys. Metallges. A.-G. No. 335,105. Dec. 7, 1928.*

Metal-extrusion presses. W. E. Evans (Hydraulik Ges., and O. Schlenstedt). No. 335,124. Dec. 5, 1929.

Method of increasing the electrical conductivity of atmospheres surrounding electric arcs used for heating or welding purposes. I. G. Farbenindustrie A.-G. No. 307,834. March 14, 1928.*

Smith's forge. J. Kopf and E. Rink No. 335,188. Apr. 8, 1929.

Automatic stereotype-plate casting-machine. Wood Newspaper Machinery Corp. No. 314,487. June 28, 1929.*

Furnaces for annealing metal sheets by a continuous process. E. Griffiths. No. 335,234. May 21, 1929.

Electro-deposition of chromium. E. V. Hayes-Gratze. No. 335,161. June 13, 1929.

Production of zinc and other metals. L. Sturbelle. No. 313,858. June 15, 1928.*

Mud guns. J. C. Hopkins and A. Osolin. No. 335,211. June 19, 1929.

Mud-gun carriages. J. C. Hopkins and A. Osolin. No. 335,212. June 19, 1929.

Casting-machines. I. D. Travis. No. 335,309. July 17, 1929.

Device for projecting sand into molds. K. Grocholl and H. Weber. No. 335,381. Oct. 5, 1928.*

Sintered alloys containing tungsten compounds. R. Walter. No. 335,453. Dec. 3, 1928*.

Manufacture of welded pipe. Air Reduction Co., Inc. No. 335,459. Dec. 10, 1928.*

Method of producing seamless tubes and pipes. P. Kiefer. No. 335,487. Jan. 21, 1929.*

Welding. Budd Wheel Co. No. 335,491. Jan. 26, 1929.*

Rolling of metal sections. K. Nolte. No. 335,497. Feb. 21, 1929.*

Hot tops for ingot molds. W. M. Charman. No. 335,480. Dec. 31, 1928.*

Soldering and metal-coating lead alloy. B. Marks (American Machine & Foundry Co.). No. 335,545. Mar. 19, 1929.

Process of improving the physical properties of steel containing copper. W. E. Evans (Vereinigte Stahlwerke A.-G.). No. 309,132. Mar. 28, 1929.

Heat-resisting alloys. W. Rosenhain and C. H. M. Jenkins. No. 335,588. Apr. 23, 1929.

Die-casting machines. H. Bradwell, *et al.* No. 335,569. Apr. 26, 1929.

Processes for purifying pig iron. F. Krupp A.-G. No. 312,361. May 25, 1928.*

Method of making wrought irons. A. M. Byers Co. Nos. 315,826; 315,827; 315,828 and 315,829. July 19, 1928.*

Process and apparatus for rising casting of ingots, slab blooms and the like. T. Brinkmann. No. 335,538. Mar. 8, 1929.*

Manufacture of metal articles. H. Wade. (Steel Sanitary Co.) No. 335,601. June 27, 1929.

Blende-sintering process. Soc. Anon. La Nouvelle Montagne. No. 335,609. Mar. 9, 1929.*

Tube-drawing machines. Soc. Anon. des Usines de Fabrication de Tubes et des Forges de Sosnowice. No. 335,647. Apr. 8, 1929.*

Production of age-resisting welded seams when welding age-resisting iron or steel alloys by the press welding process. F. Krupp A.-G. No. 316,556. July 30, 1928.*

Molding-sand projecting-machines. W. Seidemann. No 319,278. Sept. 19, 1928.*

Shears for cutting metal bars or the like. L. Mellersh-Jackson. (F. Krupp Grusonwerk A.-G.). No. 335,749. Oct. 9, 1929.

Electric induction furnaces. C. Lorenz A.-G. No. 335,766. Oct. 25, 1928.*

Fusing coatings to metal sheets. Ajax Metal Co. No. 335,769. Oct. 24, 1928.*

Producing colored patterns on metallic articles. Deutsche Gold- und Silber Scheideanstalt Vorm. Roessler. No. 335,789. Nov. 9, 1928.*

Increasing the grain-size of sulphide ores during the de-sulphurizing operation. Metallges. A.-G. No. 335,852. June 4, 1929.*

Method of protecting iron from rust. W. Böhmer. No. 335,868. Jan. 27, 1930.

Method of and blank for forming resilient rail-securing clamps. Vereinigte Stahlwerke A.-G. No. 335,872. Feb. 14, 1929.*

Apparatus for the treatment of liquid slags and the like. Norske A. for Elektrokemisk Industri. No. 335,875. Feb. 27, 1929.*

Methods of and electrodes for spot-welding copper. F. Krupp A.-G. No. 335,876. Mar. 26, 1929.*

Copper alloys. Vickers-Armstrongs, Ltd., *et al.* No. 335,950. Apr. 4, 1929.

Decarburizing of iron and steel and their alloys. Siemens & Halske A.-G. No. 314,439. June 27, 1928.*

Process and apparatus for electrolytically manufacturing metal sheets and tubes. E. Kelsen. No. 314,444. June 27, 1928.*

Electrolytic apparatus. A. E. Knowles. No. 335,987. July 6, 1929.

Forging-machines. E. B. Robinson. (E. Mernier.) No. 335,989. July 6, 1929.

Process for carrying out the electrolysis of fused electrolytes and apparatus for carrying out such process. Hirsch, Kupfer-und Messing-Werke A.-G. No. 316,969. Aug. 7, 1928.*

Manufacture and production of finely divided metals from metal carbonyls. J. Y. Johnson. (I. G. Farbenindustrie A.-G.). No. 336,007. July 10, 1929.

Process for improving high-percentage magnesium alloys. I. G. Farbenindustrie A.-G. No. 336,019. Apr. 25, 1929.*

Methods of making malleable iron. British Thomson-Houston Co., Ltd. No. 315,724. July 16, 1928.*

Stainless steel and process for the melting thereof. W. E. Martin and J. A. Berlyn. No. 336,024. July 22, 1929.

Iron or steel alloys. H. Wade. (Taylor-Wharton Iron & Steel Co.) No. 336,091. Oct. 4, 1929.

Electric resistance furnaces. W. J. Millar and Electric Furnace Co. No. 336,097. Oct. 8, 1929.

Electrolytic separation of copper. A. Mozer. No. 336,109. Oct. 29, 1928.*

Process and apparatus for controlling the movable mold parts and the pressure piston of extrusion casting-machines. P. Haessler. No. 336,129. Nov. 7, 1929.

Methods of welding. H. J. Schiffler. No. 336,195. Mar. 25, 1929.*

Welded joints. Carpmael. (I. G. Farbenindustire Akt.-Ges.). No. 317,140. (Amended specification published.)

Electric furnaces. British Thomson-Houston Co. No. 336,168. Dec. 18, 1928.*

Smelting of ores. Electro Metallurgical Co. No. 308,594. Apr. 13, 1928.*

Treating sand in foundry practice. J. E. Gernelle. No. 336,248. June 4, 1929.

Method of and apparatus for making nut-blanks. Russell, Burdsall, & Ward Bolt & Nut Co. No. 314,066. June 23, 1928.*

Method for measuring the temperatures of incandescent bodies. Kaiser-Wilhelm Instiut für Eisenforschung. No. 336,296. Oct. 31, 1928.*

Method of making sheet-metal bearing-bushes. W. H. Klocke. No. 336,333. July 30, 1929.

Mold for casting metals. A. E. White. (Aluminum, Ltd.) No. 336,337. Aug. 1, 1929.

Means for handling objects in baths, particularly for electrolytic baths. Siemens & Halske A.-G. No. 336,386. (Addition to Nos. 298,184 and 306, 379.) Jan. 28, 1929.*

Methods of welding bronze. L. J. Tibbenham. No. 336,402. Oct. 1, 1929.

Holder or clamp for use in soldering pipes. J. M. Evans. No. 336,417. Oct. 9, 1929.

Oxygen cutting-apparatus. L. J. Hancock. No. 336,433. Oct. 15, 1929.

Sand-reconditioning machines for foundry art. L. A. Camerota. No. 336,482. Nov. 26, 1929.

Refining magnesium and alloys thereof. No. 336,498. Jan. 2, 1929.*

Device for bending tubes, pipes and the like. E. C. Wright. No. 336,511. Jan. 14, 1930.

Linings for furnace arches, walls and the like. H. W. Spencer. No. 336,520. Jan. 28, 1930.

Method and means for stripping chromium plating. Ternstedt Mfg. Co. No. 336,532. Mar. 6, 1929.*

Discharge troughs for cooling beds of rolling-mill installations. F. Krupp Grusonwerke A.-G. No. 336,549. (Addition to No. 263,145.) May 24, 1929.*

Canadian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Muffle for sintering machines. The American Smelting & Refining Co., assignee of J. C. Devick. No. 304,371. Aug. 3, 1928.

Furnace arch. The Canada Fire Brick Co., Ltd., assignee of H. Clayton. No. 304,378. Oct. 9, 1928.

Anti-rust agent. Consortium für Elektrochemische Industrie, assignee of W. O. Hermann and W. Haehnel. No. 304,385. June 10, 1929.

Drawing die. The Union Drawn Steel Co., assignee of F. Kornbrath. No. 304,434. Mar. 6, 1929.

Heat treatment of magnetic materials. The Western Electric Co., Inc., assignee of G. W. Elmen. No. 304,437. Nov. 18, 1928.

Manual holder for arc-welding electrodes. The John Wood Mfg. Co., assignee of A. Marland. No. 304,443. June 7, 1929.

Method of hardening the surfaces of steel castings. E. A. Laughlin and J. R. H. Potts. No. 304,446. June 21, 1928.

Process of treating ores. T. P. Holt. No. 304,497. July 13, 1928.

Grid casting machine. A. D. Lund. No. 304,507. Aug. 19, 1929.

Electromagnetically controlled hydraulic governor for electric metallurgical furnaces. L. Tagliaferri. No. 304,529. Apr. 6, 1929.

Adjustable supporting mechanism for the straightening rolls of plate straightening machines. F. Ungerer. No. 304,535. May 11, 1929.

Converter for bessemerizing. E. I. Williams. No. 304,536. June 4, 1929.

Aluminum-base alloy and piston. (*Al-Si-Ni-Cu*). Aluminum, Ltd., assignee of R. S. Archer and L. W. Kempf. No. 304,540. June 12, 1929.

Process of operating hearth type furnaces. The American Smelting & Refining Co., assignee of H. R. MacMichael and H. A. Prosser. No. 304,543. July 4, 1929.

Method of preventing embrittlement. The Board of Trustees of the University of Illinois, assignee of S. W. Parr and F. G. Straub. No. 304,547. Oct. 2, 1929.

Lead electrode for accumulators. I. G. Farbenindustrie A.-G., assignee of G. Kranzlein and K. Muller. No. 304,578. May 23, 1928.

Apparatus for heat treating objects. F. A. Fahrenwald. No. 304,461. June 13, 1929.

Apparatus for preventing incrustations and corrosion in steam boilers. F. Hauptvogel. No. 304,693. May 16, 1925.

Apparatus for making sand cores. F. H. Morehead. Nos. 304,704 and 304,705. Sept. 17, 1929.

Recovery of tin from scrap tin plates. The African Tin Recovery Co., Ltd., assignee of M. G. Gilbert. No. 304,749. Oct. 23, 1929.

Process of preparing organic articles for electrically covering them with metallic layers. Einstein's Electrochemical Process, Ltd., assignee of K. Baranowski. No. 304,786. Feb. 28, 1930.

Metal powder. (*Obtained from the carbonyl compound.*) I. G. Farbenindustrie A.-G. No. 304,787. July 2, 1929.

Copper processing. (*Cu-Si-Fe* alloys.) W. Machin and W. B. O.' B. Goudielock. No. 304,866. July 5, 1929.

Process for the heat treatment of iron and steel. C. W. P. Heylandt. No. 304,889. Sept. 21, 1928.

Metal extruding process. L. C. Sturbelle. No. 304,920. June 12, 1929.

Steel alloy. (*Cr-Mn-W steel*). F. Krupp A.-G., assignee of E. Houdremont and V. Ehmcke. No. 304,977. Dec. 7, 1929.

Copper alloy manufacture. P-M-G Metal Trust, Ltd., assignee of U. De. Berker, *et al.* No. 304,981. Mar. 6, 1920.

Danish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for improving metals, particularly iron and steel. Ges. für Industriegasverwertung m.b.H. No. 42,890. Aug. 8, 1928.

Process for making metal ingots by centrifugal casting in rotating vertical molds. Mannesmannröhren Werke. No. 42,922. Sept. 25, 1928.

French Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for the production of aluminum or its alloys by electrothermic reduction of alumina or materials containing it. W. Neumann. No. 692,538. Mar. 21, 1930.

Process for roasting sulphide ores and other materials containing sulphur. Säurefabrik Schweizerhall. No. 692,569. Mar. 22, 1930.

Inoxidizable alloy. C. Contal. No. 692,634. June 21, 1929.

Improvements to the process for extracting tin from ores and alloys of tin and from tin slags and scrap. Soc. d'Electrochemie, d'Electrométallurgie et des Aciéries Electriques d'Ugine. No. 692,640. June 22, 1929.

Process for treating vanadium ores, particularly vanadates of lead and other metals. A. Gildemeister and E. Campagne. No. 692,654. June 24, 1929.

Hard alloy and process for making the same. Vereinigte Stahlwerke A.-G. No. 692,743. Mar. 25, 1930.

Device for elastically connecting the draw plate with the stationary support in apparatus for drawing metallic wire. J. Gurne. No. 692,358. Mar. 20, 1930.

Process for casting objects of lead or other materials. Etablissements Georges Brière. No. 692,386. June 6, 1929.

Process for making forgings bent at an acute angle, such as plowshares. J. E. J. Languepin. No. 692,405. June 13, 1929.

Process and apparatus for welding objects made of duralumin, aluminum and aluminum alloys. Soc. a Responsibilité Limité "La Lhocoryne." No. 692,416. June 14, 1929.

Roller bearing for heavy-duty rolling mill rolls. Maschinenbau A.-G. vormals Ehrhardt & Sehmer. No. 692,496. Mar. 21, 1930.

Means for cooling castings. J. C. F. Leininger. No. 692,517. Mar. 21, 1930.

Improvements to solders. Westinghouse Electric & Mfg. Co. No. 692,545. Mar. 21, 1930.

Automatic machine with magnetic plates, for controlling arcs. R. Sarazin. No. 692,605. Mar. 24, 1930.

Machine for casting metals. A D. Lund. No. 692,706. Mar. 21, 1930.

Process for removing a layer of lead from metallic objects. Dudzeele Corp. of America. No. 692,721. Mar. 25, 1930.

Automatic machine for slinging sand into foundry molds. F. Henon. No. 692,811. Mar. 27, 1930.

Luting for the joints of foundry molds. J. B. Durand. No. 692,818. Mar. 27, 1930.

Process for enlarging hollow bodies. F. Kochs. Addition No. 37,368. (First addition to No. 669,169 filed Feb. 5, 1929.) Aug. 24, 1929.

Electrolytic process for chromium-plating metals. Electro-Métaux. No. 692,444. June 17, 1929.

Apparatus for the electrolytic production of light metals. Soc. pour l'Indutrie Chimique à Bâle. No. 692,491. Mar. 21, 1930.

Process for the electrolytic formation of tin coatings, particularly tin plate in alkaline electrolytes. Siemens & Halske. No. 692,813. Mar. 27. 1930.

Rust- and corrosion-resistant steel and process for making the same. G. Muller. No. 692,887. Mar. 28, 1930.

Rolling mill installation. Morgan Construction Co. No. 693,033. Mar. 29, 1930.

Process for making compound iron castings by the use of partitions. W. Alberts and F. Stein. No. 693,041. Mar. 29, 1930.

Framework for holding the shafts of metallurgical furnaces. Dingler Maschinenfabrik A.-G. No. 693,045. Mar. 29, 1930.

Solder. E. E. Meunier. No. 692,848. Mar. 25, 1930.

Improvements in the rolling of metals. The Cold Metal Process Co. No. 692,879. Mar. 28, 1930.

Process for joining metallic objects by soldering. N. V. Philips' Gloeilampenfabrieken. No. 692,899. Mar. 28, 1930.

Apparatus for the continuous molding and casting of metallic objects. Soc. des Usines du Pied-Selle. No. 692,947. July 1, 1929.

Process and apparatus for making hollow bodies of revolution having a bottom and a single or double wall. Westfalische Metallwerke Goerch & Cie. Kommanditges. and W. Klochner. No. 693,030. Mar. 29, 1930.

Rolling mill installation. Morgan Construction Co. No. 693,075. Mar. 31, 1930.

Improvements in the rolling of metals. The American Rolling Mill Co. No. 693,085. Mar. 31, 1930.

Process for improving magnesium alloys, particularly objects made of such alloys. I. G. Farbenindustrie A.-G. No. 693,204. Apr. 2, 1930.

Improvements to processes for producing magnesium. The Magnesium Production Co., Ltd., assignee of P. Camescasse. No. 693,387. Apr. 4, 1930.

Molds for casting copper and method of molding. The American Metal Co., Ltd. No. 693,094. Mar. 31, 1930.

Machine for straightening shafts or bars. E. Jacques. No. 693,123. Apr. 1, 1930.

Process for cleaning metal surfaces. The Bullard Co. No. 693,199. Apr. 2, 1930.

Process for eliminating carbon from difficultly fusible rare metals, particularly, tantalum. Fansteel Products, Inc. No. 693,417. Apr. 5, 1930.

Improvements to iron alloys. B. D. Saklatwalla. No. 693,418. Apr. 5, 1930.

Process for making and refining alloys of magnesium and cerium. I. G., Farbenindustrie A.-G. No. 693,544. Apr. 8, 1930.

Heating elements for electric heat treating furnaces. E. F. Russ. No. 693,413. Apr. 5, 1930.

Process for making iron or steel which is not subject to magnetic aging. Vereinigte Stahlwerke A.-G. No. 693,602. Apr. 9, 1930.

Method of slinging sand, for foundry molding machines. H. Weber and K. Grocholl. No. 693,636. Oct. 4, 1929.

Starting cathodes for the electrolytic refining of copper and other metals. United States Metals Refining Co. No. 693,678. Apr. 10, 1930.

Improvements to mechanical coolers for rolling mill installations. Soc. d'Etudes et de Constructions Métallurgiques and A. Grosbost. No. 693,738. July 22, 1929.

Process for making refractory chromium alloys containing aluminum and titanium. S. A. des Anciens Etablissments Skoda à Pilzen. No. 693,775. Apr. 11, 1930.

Electrolytic bath of iron salts for the electrolytic production of iron or iron alloys. O. Orlandi. No. 693,812. Apr. 12, 1930.

Control mechanism for machines for closing tap holes. William M. Bailey Co. No. 693,826. Apr. 12, 1930.

Process and machine for making pins or rivets having an upset head out of a hard non-ferrous alloy containing copper. E. Soltau. No. 693,579. Apr. 9, 1930.

Core for motor cylinders. Soc. Fermiere des Fonderies et Aciéries de Paris et de la Seine. No. 693,752. Apr. 11, 1930.

Chaplet. A. E. A. Orland and I. Foskajaer. No. 693,764. Apr. 11, 1930.

Process for joining tubes end-to-end. Vereinigte Stahlwerke A.-G. No. 693,779. Apr. 11, 1930.

Process for degreasing, cleaning and drying metallic objects. H. Lautmann. No. 693,861. Apr. 14, 1930.

Process for making sheet and foil of corrosion-resistant aluminum. Vereinigte Silberhammerwerke Hetzel & Co. No. 693,869. Apr. 14, 1930.

Improvements to suspended arches for industrial furnaces. M. Gilbert. No. 693,588. Apr. 9, 1930.

Suspended roof for furnaces, built of individually suspended blocks. Vereinigte Stahlwerke A.-G. No. 693,761. Apr. 11, 1930.

Device for automatically assuring the tightness of furnace joints. E. J. Franklin. No. 693,777. Apr. 11, 1930.

Process for making hollow drill steels, tubing and similar objects. Schoeller-Bleckmann Stahl Werke. No. 694,050. Apr. 16, 1930.

Improvements in the bessemerization of mattes or materials containing nickel. The International Nickel Co., Inc. No. 694,092. Apr. 17, 1930.

Acid-resistant alloy. S. A. des Anciens Etablissments Skoda à Pilzen. Addition No. 37,433. (First addition to No. 681,578 filed Sept. 10, 1929.) Sept. 12, 1929.

Process for preventing the formation of white rust. K. Daeves. No. 693,905. Apr. 14, 1930.

Reservoir for casting liquid metal without the use of pressure. A. E. A. Orland and I. Foskjaer. No. 693,926. Apr. 15, 1930.

Two piece foundry mold. A. E. A. Orland and I. Foskjaer. No. 693,927. Apr. 15, 1930.

Control device for flying shears. Morgan Construction Co. No. 693,963. Mar. 28, 1930.

Device for casting bearings. R. Fuchs. No. 693,984. Apr. 15, 1930.

Improvements to process and apparatus for making objects of tubular shape. The Youngstown Sheet & Tube Co. No. 693,987. Apr. 15, 1930.

Improvements to autogenous welding stations. C. D. J. Legrand. No. 694,085. Apr. 17, 1930.

Process for welding magnesium and its alloys. I .G. Farbenindustrie A.-G. No. 694,137. Apr. 18, 1930.

Process for making shaped metallic objects. I. G. Farbenindustrie A.-G. Addition No. 37,430. (First addition to No. 682,162 filed Aug. 5, 1929.) Sept. 11, 1929.

Improvements to presses for stamping sheet metal. C. J. Rhodes. Addition No. 37,445. (First addition No. 641,351 filed Sept. 23, 1927.) Sept. 19, 1929.

Method and instrument for determining the temperature of incandescent matter. R. Weisert. No. 693,938. Apr. 15, 1930.

Control and measurement of temperatures. Cie. Française pour l'Exploitation des Procédés Thomson-Houston. No. 693,982. Apr. 15, 1930.

Device for passing suspended objects through baths, particularly electrolytic baths. Siemens & Halske A.-G. Addition No. 37,457. (First addition to No. 661,294 filed Sept. 24, 1929.)

Method of storing and transporting acetylene, particularly for the autogenous working of metals. I. G. Farbenindustrie A.-G. No. 694,001. Apr. 15, 1930.

Tuyères or similar objects working under similar conditions. Heraeus Vacuumschmelze A.-G. and W. Rohn. No. 694,141. Apr. 18, 1930.

German Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Coiling drum for strips of steel and other metals. Siegener Maschinenbau A.-G. No. 509,247. Sept. 4, 1929.

Hydraulic drawbench. Adolf Kreuser G.m.b.H. No. 509,147. July 1, 1928.

Process for the production of alumina from bauxite. Metallges. A.-G. No. 509,131. June 2, 1926.

Decomposing zirconium ores. Kali-Chemie A.-G. No. 509,514. Dec. 14, 1926.

Grooved and ribbed checker brick for the regenerator chambers of regenerative furnaces, blast heaters and the like. W. Schwier. No. 509,501. May 9, 1926.

Device for hardening the flanks of screw threads or worm gearing by means of an autogenous burner mounted above a quenching liquid. F. Klopp. No. 509,525. Mar. 13, 1929.

Three-phase high-temperature furnace. Elektro-Schalt-Werk A.-G. No. 509,182. May 12, 1928.

Electric furnace. Siemens-Schuckertwerke A.-G. No. 509,286. Aug. 6, 1927.

Heating-resistance support. Siemens-Schuckertwerke A.-G. No. 509,287. Sept. 27, 1927; in the United States Oct. 7, 1926.

Alternating-current melting furnace, with electrodes and single-phase transformers. A.-G. für Stickstoffdünger. No. 509,421. Dec. 9, 1927.

High-frequency furnace with concentric windings outside the crucible. Siemens-Schuckertwerke A.-G. No. 509,537. Sept. 16, 1926.

Muffle furnace with combined fuel and electric heating. Allgemeine Electricitäts Ges. No. 509,288. Feb. 9, 1929.

Process for making grooved rolls. Herm. Irle G.m.b.H. No. 509,243. Sept. 2, 1926.

Apparatus for dead-roasting fine-grained or pulverulent material. Balz-Erzröstung G.m.b.H. No. 509,306. Dec. 4, 1926.

Melting pot for separation by crystallization. Metallhüttenwerke Schaefer & Schael A.-G. No. 509,307. Aug. 7, 1927.

Method of preventing the warping of very narrow, strip-shaped parts in cutting with a cutting burner. Siemens-Schuckertwerke A.-G. No. 509,321. Aug. 22, 1928.

Multiple wire drawing machine. W. Nacken. No. 509,811. (Addition to No. 457,855.) Aug. 13, 1929.

Device for intermittently feeding strip and sheet material to presses and the like. Maschinenfabrik Weingarten vorm. Hch. Schatz A.-G. No. 509,920· June 6, 1928.

Framework for supporting the shafts of metallurgical furnaces. Dingler'sche Maschinenfabrik A.-G. No. 510,206. Aug. 3, 1929.

Method of operating burners especially large gas burners for Cowper stoves. Askania-Werke A.-G. vorm. Centralwerkstatt Dessau und Carl Bamberg-Friedenau. No. 510,207. Aug. 6, 1927.

Pot annealing furnace, particularly for annealing wire, strip and the like. Ernst Beckert Nadelfabrik Com.-Ges. No. 510,208. Jan. 26, 1927.

Roller furnace with inclined runway and conveying device, for annealing pipes. M. Schlipköter. No. 510,209. Jan. 8, 1928.

Process for making electric heating resistances out of carbon and metallic oxides. Electroterm A.-G. No. 510,068. Apr. 4, 1928.

Heating furnace with a heating element heated by electricity, gas or the like. R. Frister A.-G. No. 509,958. Dec. 15, 1928.

Method of building induction furnaces. Allegemeine Elektricitäts Ges. No. 509,726. Jan. 1, 1927; in the United States Dec. 31, 1925.

Purification of liquors containing bismuth. F. Spira. No. 510,140. June 16, 1929.

Treatment of iron pyrites containing copper, zinc and lead. S. I. Levy and G. W. Gray. No. 510,139. Mar. 11, 1928.

Tunnel furnace. H. Koppers A.-G. No. 509,787. Mar. 20, 1929.

Return guide for stock in rolling mills. Fried. Krupp Grusonwerk A.-G. No. 510,893. Feb. 27, 1929.

Housing element for the bearings of the backing rolls of multi-roll rolling mills. Fried. Krupp Grusonwerk A.-G. No. 510,559. Jan. 19, 1929.

Process for drawing highly polished steel bars. C. Köchling. No. 510,887. Apr. 12, 1927.

Three-roll sheet-bending machine for making pipe or tubing. Weberwerke. No. 510,894. Jan. 1, 1928.

Process for making metallic tubing in an extrusion press. Hydraulik G.m.b.H. and O. Schlenstedt. No. 510,895. Feb. 12, 1929.

Draw-bench with a cutting-off device. Siemens-Schuckertwerke A.-G. No. 510,907. Nov. 7, 1926.

Machine for stamping armature sheets for electric motors having a tapered seat for the armature. Sachsenwerk Licht-und-Kraft A.-G. No. 510,798. Sept. 14, 1928.

Press with automatic feed for making parallel series of cuts or holes in uncut sheets of material. R. Stübgen. No. 510,799. (Addition to No. 508,474.) Dec. 28, 1929.

Process for making tubing. Addiator G.m.b.H. No. 510,566. Jan. 15. 1928.

Wheel-disk rolling mill with conical rolls, particularly for the wheel disks of automobile wheels whose thickness decreases toward the periphery. Maschinenbau A.-G. vormals Ehrhardt & Sehmer. No. 510,800. Apr. 19, 1928.

Transverse grating for the discharge runway at the end of the welding hearth of an ingot-heating furnace. Friedrich Siemens A.-G. No. 510,458. Sept. 29, 1929.

Method of operating multi-channel induction melting furnaces. H. Zepernick. No. 510,599. Nov. 20, 1927.

Rotary melting furnace. E. Weiss. No. 510,492. Sept. 17, 1929.

Molding machine in which the mold boards and flasks are carried by cars moving on an endless track. Automatic Moulding Machines, Ltd. No. 510,742. Jan. 29, 1928; in Great Britain Feb. 8, 1927.

Core-molding machine. Mitteldeutscher Stahlwerke A.-G. No. 510,692, July 1, 1928.

Jarless jolt-molding machine with swinging arms and roll-over plates. The Tabor Mfg. Co. No. 510,743. (Addition to No. 483,294.) June 4, 1929; in the United States Nov. 24, 1928.

Jolt-molding machine with geared drive for the roll-over mechanism. The Tabor Mfg. Co. No. 510,493. July 12, 1928; in the United States Feb. 3, Jan. 3, and Jan. 17, 1928 and Nov. 11, 1927.

Machine for making molds, using a highly accelerated metering current of compressed air. Badische Maschinenfabrik & Eisengiesserei vormals G. Sebold and Sebold & Neff. No. 510,494. Dec. 13, 1928.

Twin pressure-molding machine. G. Zimmermann. No. 510,941. Mar. 15, 1929.

Process and device for making molds in flasks provided with cross bars. W. Mann. No. 510,495. Mar. 16, 1929.

Hot top for ingot molds. W. H. Ramage. No. 510,496. Aug. 11, 1927.

Process for making segregation-free hollow castings. M. Roeckner and C. Daeves. No. 510,497. June 7, 1929.

Tubular core for use in making hollow castings. Vereinigte Stahlwerke A.-G. No. 510,942. Aug. 17, 1929.

Tilting chill mold, mounted on trunnions. F. Stuhl. No. 510,358. Mar. 29, 1929.

Centrifugal casting machine having mold segments which are displaceable radially and perpendicularly with respect to the end plate. David Brown & Sons, Ltd., and D. Brown. No. 510,498. Aug. 5, 1927; in Great Britain Aug. 11, 1926.

Means for conveying the metal into the pouring trough of centrifugal casting machines. Centrifugal Castings, Ltd. No. 510,499. Dec. 11, 1928; in Great Britain Jan 4, 1928.

Drive for a centrifugal casting machine having a plurality of molds mounted on a turn table. W. A. Harrington. No. 510,500. June 15, 1928.

Method of increasing the life of steel centrifugal casting molds. International de Lavaud Mfg. Corp., Ltd. No. 510,359. May 10, 1928; in the United States June 8, 1927.

Method of making sand beds for elastic negatives. A. Grossmann. No. 510,360. Mar. 7, 1929.

Continuous casting machine in which the bottom of the mold is closed by a closure element made of a refractory material. S. Junghamns. No. 510,361. June 11, 1927.

Process for making zinc cups for battery elements. A. Gassan. No. 510,829. (Addition to No. 495,983.) Oct. 30, 1928.

Process for making jaws for cam brakes. Fiat S. A. No. 510,364. June 2, 1929.

Means for holding together the two halves of a mold. Internationale Metall A.-G. No. 510,365. Nov. 6, 1928; in Austria Feb. 10, 1928.

Melting pot arrangement for die casting machines. Präzisionsguss- Fabrik Nürnberg Gebr. Eckert. No. 510,366. Jan. 23, 1929.

Nozzle for cleaning castings with a jet of water under pressure. Badische, Maschinenfabrik & Eisengiesserei vormals G. Sebold and Sebold & Neff. No. 510,367. Aug. 22, 1929.

Process for working up arsenical materials, particularly those containing arsenic and cadmium. Otavi Minen- und Eisenbahnges. No. 510,750. July 11, 1929.

Apparatus for the electrolytic precipitation of metals. Imperial Chemical Industries, Ltd. No. 510,618. Jan. 19, 1929; in Great Britain Feb. 25, 1928.

Method and instrument for determining the wall thickness of changes in cross-section of iron and steel tubes. P. Bloss. No. 510,839. Mar. 26, 1927; in Hungary Apr. 14, 1926.

Process for coloring metals. A. Pacz. No. 510,380. Oct. 30, 1927.

Device for the coördinated delivery of objects from multiple-tool presses. Fledermaus A.-G. für Metallindustrie und Maschinenbau. No. 510,651. Jan. 26, 1930.

Cutting or welding machine. A.-G. für Tiefbohrtechnik and Maschinenbau vormals Trauzl & Co. No. 510,653. Aug. 6, 1929; in Austria July 13, 1929.

Process for pressing chamotte, dinas and other brick out of a dry or semi-dry mix. R. Augustin. No. 510,556. June 21, 1928.

Liquid-fuel welding and cutting burner. S. Weil and G. Lotzow. No. 511,373. Oct. 17, 1928; in France Oct. 10, 1928.

Burner for the autogenous welding of longitudinal seams. Hager & Weidmann A.-G. No. 511,196. Dec. 23, 1928.

Device for cleaning the dies of wire-drawing machines. A. Hesse. No. 511,104. Oct. 7, 1928.

Multiple wire-drawing machine. W. Nacken. No. 511,090. Aug. 9, 1927.

Device for holding the draw-plate of wire-drawing machines. Electrical Research Products, Inc. No. 511,375. Aug. 5, 1927.

Double press for piercing and drawing billets. A. Kreuser G.m.b.H. No. 511,450. (Addition to No. 496,829.) Sept. 28, 1928.

Process for making U-shaped pipe sections. H. Frank. No. 511,524. Feb. 10, 1929.

Process for making sectional shapes having uniform wall thickness out of strips, particularly those made of magnesium or magnesium alloys. I. G. Farbenindustrie A.-G. No. 511,460. Oct. 4, 1928.

Press in which the material is automatically fed, for the production of parallel series of cuts or holes in uncut sheets of material. R. Stübgen. No. 511,199. (Addition to No. 508,474.) Dec. 28, 1929.

Drawpress. C. J. Rhodes. No. 511,200. Sept. 18, 1929; in Great Britain Dec. 17, 1929.

Tubing roll. G. Burkhardt. No. 511,113. (Addition to No. 504,495.) Mar. 20, 1928.

Process for lap-welding tubing. J. Steinnes. No. 511,461. Sept. 9, 1926.

Process for making sheet-metal radiators. W. & F. Dinkel. No. 511,315. Sept. 18, 1928.

Application of the process of Patent No. 500,692 to other metallic carbonyls than iron carbonyl or to any mixtures of carbonyls. I.-G. Farbenindustrie A. G. No. 511,564. (Addition to No. 500,692.) July 7, 1926.

Process for roasting ores. Hundt & Weber G.m.b.H. No. 511,385. Oct. 10, 1928.

Process for making a lining for converters and other metallurgical furnaces. Comptoir technique Albert Knaff & Leon Mayer. No. 511,117. (Addition to No. 469,863.) Oct. 19, 1928.

Electric heating element. Heraeus-Vacuumschmelze A.-G. and W. Rohn. No. 511,097. Dec. 2, 1927.

Electric soldering iron. P. Neumann. No. 511,042. Dec. 30, 1926.

Temperature indicating device for electric furnaces. E. C. Glitzke. No. 511,238. Nov. 22, 1927.

Device for annealing metallic thread and wire with the aid of an electric current. Firma Christian Wandel. No. 511,327. June 22, 1927.

Arc-welding machine. Allgemeine Elektricitäts Ges. No. 511,328. Feb. 17, 1926; in the United States Feb. 16, 1925.

Process for making a salt mixture for welding and soldering purposes, particularly for coating welding rods. La Soudure Electrique Autogène S. A. No. 511,329. July 12, 1928; in France June 26, 1928.

Cupola with refining hearth. P. Marx. No. 511,242. (Addition to No. 469,704.) Jan. 4, 1930.

Electric melting furnace. Siemens-Schuckertwerke A.-G. No. 511,052. June 29, 1929.

Electromagnetic jarring device, particularly for foundry purposes. Siemens-Schuckertwerke A.-G. No. 511,243. May 9, 1929.

Coating for the inner surfaces of permanent molds. F. Mayer. No. 511,101. Oct. 30, 1923.

Crucible tongs for foundries. W. Arcona. No. 511,534. Feb. 9, 1929.

Recovery of noble metals by amalgamation. D. Enzlin and J. A. Eklund. No. 511,334. Aug. 19, 1928.

Electrolytic bath for stripping chromium-plated objects. Ternstedt Mfg. Co. No. 511,416. Feb. 12, 1930; in the United States Mar. 6, 1929.

Apparatus for condensing zinc vapor. F. Juretzka. No. 511,484. Jan. 27, 1927.

Rotary shear for cutting moving rolled material. Demag A.-G. No. 511,496. Sept. 12, 1926.

Device for cutting and measuring off moving material. Steel and Tubes Inc. No. 511,277. June 22, 1928; in the United States Apr. 21, 1928.

Process for die-pressing objects out of high-strength aluminum alloys, the material being heated to about 500° C. before pressing. Vereinigte Aluminium-Werke A.-G. No. 511,192. Mar 18, 1926.

Process for welding chain links in which the portions of the links which are to be welded are brought to welding heat and subjected to the action of a current of compressed gas. K. Hüppelshäuser. No. 511,431. Sept. 1, 1928.

Process for making metallic bronzing powder. Hartstoff-Metall A.-G. No. 511,369. (Addition to No. 410,514.) Oct. 23, 1928.

Process for straightening out thin metal strips being drawn from a reel by the rolls of a cold-rolling mill. W. Bauer. No. 511,879. Dec. 31, 1929.

Process for cold-stretching tubular objects. August Enders A.-G. No. 511,791. Feb. 17, 1927.

Press tool. P. C. Christiansen. No. 511,732. Feb. 26, 1929; in Denmark Mar. 1, 1928.

Protective device for spindle presses. R. Surtees. No. 511,804. Dec. 4, 1926; in Great Britain Feb. 15, 1926.

Process and machine for producing rods, shaft portions and the like having a non-cylindrical shape. Kerb-Konus G.m.b.H. No. 511,881. May 2, 1926.

Apparatus for heat treating rails in a chamber, with provision for passing electric currents through the rails. C. W. St. J. Rowlandson. No. 512,036. Apr. 4, 1928.

Protective device for the electrodes of electric furnaces. Siemens & Halske A.-G. No. 512,055. June 1, 1929.

Rotary melting furnace. Gewerkschaft Eisenhütte Westfalia. No. 512,119. Apr. 18, 1928.

Coal-dust-fired melting furnace. W. Reitmeister. No. 511,665. June 14, 1929.

Mold for casting copper alloys under a vacuum. P. Ziegs. No. 512,060. Mar. 5, 1929.

Process for making composite castings. Vereinigte Stahlwerke A.-G. No. 512,061. Feb. 14, 1930.

Centrifugal casting machine for making hollow bodies. Soc. Alta Forni, Fonderie, Acciaierie e Ferriere Franchi-Gregorini. No. 512,062. June 7, 1928.

Device for molding sand cores for red brass bearing backs for locomotives. Metallges. A.-G. NO. 511,750. Apr. 17, 1928.

Heating and melting furnace. R. Gunka. No. 511,596. Nov. 1, 1927; in France Nov. 2 and Dec. 18, 1926 and Sept. 27, 1927.

System of treating bulk articles in electrolytic baths. Siemens & Halske A.-G. No. 511,922. Sept. 23, 1928.

Mixture for aluminothermic welding. Elektro-Thermit G.m.b.H. No. 511,990. Apr. 18, 1929.

Flask for aluminothermic rail welding. Elektro-Thermit G.m.b.H. No. 511,766. Dec. 14, 1929.

Aluminothermic mixture. Th. Goldschmidt A.-G. No. 511,991. June 22, 1926; in France July 29, 1925.

Machine for welding circular seams. Svenska AB. Gasaccumulator. No. 511,926. June 6, 1929; in Sweden June 22, 1928.

Hole-cutting device. H. Propfe & Co. m.b.H. No. 511,927. Oct. 10, 1929

Italian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Improvements to alloys and to metal foil. American Machine & Foundry Co. No. 270,080. June 12, 1928.

Method of treating ores and the like to recover metals, for example to make manganese steel alloys. Bradley Fitch Co. No. 270,305. July 2, 1928.

Process for the electrodeposition of cadmium. Grasselli Chemical Co. No. 269,996. May 30, 1928.

Method of electrically heating furnaces, such as melting, heat-treating and hardening furnaces, by means of heating resistances carrying induced currents. W. Hammer. No. 270,039. May 28, 1928; in Germany June 2, 1927.

Steel alloys and their manufacture. L. Polzella. No. 269,912. May 18, 1928.

Electrolytic chromium-plating process and electrolyte for use therein. Ternstedt Mfg. Co. No. 270,011. June 12, 1928; in the United States June 13, 1927 in the name of F. K. McCullough and B. W. Gilchrist.

Process for making low-carbon gray cast iron of any desired structure. Maschinenfabrik Esslingen. No. 269,956. (First addition to No. 253,760 filed Nov. 5, 1926.) May 23, 1928; in Germany May 27, 1927.

Method of obtaining anhydrous aluminum oxide at low temperature. Soc. Italiana Potassa. No. 269,815. Mar. 7, 1928.

Improvements to apparatus for the electrodeposition of metals on small objects in bulk. Cambiaggio, Salvaneschi & C. No. 270,194. June 8, 1928.

Protective method for autogenous welding. I. G. Farbenindustrie A.-G. No. 270,129. June 4, 1928.

Apparatus for electric welding. M. Haagen. No. 269,926. May 25, 1928; in Luxembourg May 27, 1927 in the name of A. Sund.

Mold for the centrifugal casting of pipes and method of making said mold. International De Lavaud Mfg. Corp., Ltd. No. 269,735. May, 12, 1928; in the United States June 8, 1927 in the name of J. H. Uhrig.

Process for raising the elastic limit of hollow bodies of alloy steel, particularly of austenitic steel whose elastic limit cannot be raised by heat treatment. F. Krupp A.-G. No. 270,093. June 6, 1928; in Germany June 23, 1927.

Method and apparatus for the heat treatment of metals and other substances. Surface Combustion Co. No. 270,038. May 31, 1928; in the United States June 2, 1927 in the names of R. M. Heames, *et al.*

Process for recovering tin from scrap tin plate. L. U. La Corsa. No. 270,177. June 2, 1928.

Apparatus for electroplating objects in bulk, particularly for chromium plating. V. Zanotti. No. 269,936. (First addition to No. 265,372 filed Dec. 15, 1927) Jan. 10, 1928.

Method of charging electric furnaces. I. G. Farbenindustrie A.-G. No. 269,917. May 18, 1928; in Germany May 18, 1927.

Improvements to furnaces for heating and annealing metals and the like. T. A. Kathner. No. 269,832. May 11, 1928.

Melting furnace fired with vaporized oils and steam, or with oil and superheated compressed air. V. Marciano. No. 270,211. Sept. 18, 1926.

Improvements to electric furnace electrodes. Soc. Electrométallurgique de Montricher. No. 269,885. May 29, 1928; in France Mar. 31, 1928.

Improvements to furnace linings. W. H. Wildish. No. 270,186. June 14, 1928; in Great Britain July 2, 1927. (British Patent No. 293,195.)

Process for the deoxidation of oxidized metallic surfaces and for the protection of metallic surfaces against oxidation. "Kolloidchemie" Studienges. m.b.H. *et al.* No. 269,756. May 7, 1928.

Electrolyzer for the separation of tin from solutions of tin salts. L. U. La Corasa. No. 270,221. June 9, 1928.

Process for decreasing overvoltage in electrolytic elements. A. Vogel. No. 270,136. June 12, 1928; in Germany June 14, 1927.

Improvements in the extraction of tin from ores and materials containing it. A. E. Ashcroft. No. 270,891. July 4, 1928; in Great Britain July 7, 1927.

Process for making ore briquettes. E. A. A. Grönwall. No. 271,010. June 16, 1928; in Sweden July 23, 1927.

Process for making a very hard metallic composition. Cia. Generale di Elettricita. No. 270,902. (First addition to No. 268,378 filed Apr. 6, 1928.) Apr. 18, 1928; in the United States Apr. 28, 1927 in the name of E. G. Gilson. No. 270,913. (Second addition to No. 268,378 filed Apr. 6, 1928.) July 4, 1928; in the United States July 15, 1927 in the name of E. G. Gilson. (U. S. Patent No. 1,671,953.)

Improvements to method for making nickel compositions, particularly for use in making anodes. International Nickel Co. No. 271,113. July 5, 1928; in the United States Nov. 28, 1927 in the names of W. J. Harshaw, *et al.*

Antifriction metal of the ternary system copper–antimony–lead. S. Deiches. No. 270,907. (First addition to No. 250,025 filed July 5, 1926.) June 16, 1928; in Austria June 24, 1927.

Magnesium alloy for pistons of internal combustion engines. I. G. Farbenindustrie A.-G. No. 270,507. (First addition to No. 261,127 filed Aug. 13, 1927.) July 4, 1928; in Germany July 4, 1927.

Process for making iron and steel which is not subject to cold-shortness, blue-brittleness and to aging. J. H. van Royen. No. 270,498. (First addition to No. 266,532 filed Feb. 18, 1928.) June 11, 1928; in Germany Aug. 9, 1927.

Improvements to corrosion-resistant alloys and to methods of making the same American Machine & Foundry Co. No. 271,091. July 12, 1928.

Process and apparatus for making sponge metal. G. H. Flodin. No. 271,033. July 13, 1928; in Sweden July 14, 1927.

Material composed of corrosion-resistant metals and alloys, particularly copper for covering roofs, walls and other surfaces. Metallbank und Metallurgische Ges. A.-G. No. 270,398. June 22, 1928; in Germany June 23, 1927.

Process for drawing rods or round bars of steel, silver steel, high speed steel or the like giving high polish and perfectly uniform cross-section. H. Möller. No. 270,961. July 2, 1928.

Method of automatically regulating the current in electric tubing-welding machines. "Omes" S.A. No. 270,966. July 2, 1928.

Machine for making molds for casting hollow bodies. A. Possenti and C. Scorza. No. 270,350. June 18, 1928.

Roller bed with individual electric drive for the conveying rollers. B. Quast and F. Lemberg. No. 270,694. July 5, 1928.

Process for welding with radiant heat. E. Schroeder. No. 270,449. June 22, 1928; in Germany June 28, 1927.

Process for making seamless tubing. J. Severini. No. 270,936. June 25, 1928; in Germany July 16, 1927.

Improvements in the case hardening of metals. W. P. Shimer and B. E Shimer. No. 270,561. June 12, 1928; in the United States June 22, 1927.

Process for making alloy sections by pressing and heat treatment of the same. S. A. pour l'Industrie de l'Aluminium. No. 270,795. July 2, 1928.

Method of and apparatus for the feeding of molten metal in the centrifugal casting of hollow bodies having the shape of a solid of revolution. A. Possenti and C. Scorza. No. 270,916. (First addition to No. 258,779 filed May 20, 1927.) July 31, 1928.

Composition for the autogenous welding of aluminum. W. Reuss. No. 270,673. (First addition to No. 264,090 filed Nov. 10, 1927.) June 9, 1928; in Germany Feb. 15, 1928.

Improved electric furnace. F. T. Baily. No. 271,145. July 12, 1928; in the United States July 19, 1927. (U. S. Patent No. 1,675,744.)

Electric furnace for annealing metals, particularly malleable cast iron. H. Zimmer. No. 271,052. June 23, 1928.

Improvements to electrolytic apparatus for refining aluminum or for similar operations. Cie. de Produits Chimique et Electrométallurgique Alais, Froges et Camargue. No. 270,548. June 10, 1928; in France July 4, 1927 in the names of F. da Paul and L. Hulin.

Norwegian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Method of pressing the blank in the production of electrically welded tubing. F. Sonnichsen *et al.* No. 48,426. Dec. 31, 1928.

Alloy for wires or strips for loading telephone conductors. W. S. Smith and H. J. Garnett. No. 48,494. June 1, 1926.

Magnetic alloys. W. S. Smith and H. J. Garnett. No. 48,495. Jan. 18, 1927.

Device for the automatic control of furnaces. Westinghouse Electric & Mfg. Co. No. 48,496. Jan. 25, 1928.

Process for making continuous electrodes. Gebr. Siemens & Co. No. 48,497. Nov. 29, 1927.

Process and apparatus for mixing and refining molten metals and alloys. F. W. Corsalli. No. 48,524. June 17, 1927.

Swedish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Machine for the continuous production and drying of briquettes. Flodinjern AB. No. 70,553. Aug. 30, 1926.

Process for tinning rustless steel. AB. Separator. No. 70,613. Dec. 18, 1929.

Soldering device for soldering the wires of incandescent lamps. N. V. Philips' Gloeilampenfabrieken. No. 70,614. Mar. 27, 1926. Priority date May 15, 1925.

Plate press. C. J. Rhodes. No. 70,631. Apr. 22, 1929.

Air-tight connection for electric heating resistance wires. W. B. Smits. No. 70,462. Feb. 14, 1929. Priority date Feb. 23, 1928.

Self-baking electrode. Det Norske A/S for Elektrokemisk Industri. No. 70,695. May 6, 1926. Priority date June 23, 1926.

Electrically-driven rolling mill roll. Demag A.-G. No. 70,717. Sept. 30, 1929.

Method and apparatus for determining certain physical properties of metals in the production of objects therefrom. American Chain Inc. No. 70,743. Mar. 31, 1924. Priority date July 24, 1927.

Process for preventing decarburization during the annealing or heat treatment of steel. Fagersta Bruks AB. No. 70,764. Apr. 3, 1928.

Swiss Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for forming a corrosion-preventing protective layer on metallic surfaces. "Koloidchemie" Studienges. m.b.H., *et al.* No. 140,108. June 4, 1928.

Process for making antifriction alloys. A. E. Ricard and L. Daniel. No. 140,172. Oct. 21, 1929.

Process for making an alloy of refractory metallic carbides and a lower melting element. F. Krupp A.-G. No. 140,173. May 1, 1929; in Germany May 2, 1928.

Partition for separating the products of electrolysis in the fusion electrolysis of chlorides, particularly that of magnesium. I.-G. Farbenindustrie A.-G. No. 140,174. Nov. 16, 1928; in Germany Dec. 23, 1927.

Process for making chromium-rich pre-alloys. J. Härdén and H. Tillquist. No. 140,175. July 30, 1929.

Process for making ingots of non-ferrous metals, for rolling and pressing. Vereinigte Aluminium-Werke A.-G. No. 140,176. June 18, 1929.

Aluminum solder. E. Stirnemann and A. Perret. No. 140,177. July 13, 1927.

Process for making a welding composition for metals and alloys, particularly for aluminum. W. Reuss. No. 140,178. Nov. 7, 1929.

Air- and acid-tight sealing of resistance wires. W. B. Smits. No. 140,179. Feb. 22, 1929; in Czechoslovakia Feb. 23, 1928.

Welding generator with divided windings. "Elin" A.-G. für elektrische Industrie. No. 140,180. Apr. 22, 1929; in Austria May 25, 1928.

Multiple wire-drawing machine. Berkenhoff & Drebes A.-G. No. 140,181. June 4, 1929.

Process for improving aluminum alloys. Th. Goldschmidt A.-G. No. 140,183. Oct. 20, 1926; in Germany Oct. 21, 1925.

Process for cooling metals in closed vessels. Siemens-Schuckertwerke A.-G No. 140,184. July 26, 1929; in Germany Oct. 22, 1928.

Process for preventing carbon electrodes from burning in the air. I. G. Farbenindustrie A.-G. No. 140,250. Nov. 19, 1928; in Germany Dec. 23, 1927.

Electric resistance furnace. Wild-Barfield Electric Furnaces, Ltd. and L. W. Wild. No. 140,251. May 31, 1929.

Process for obtaining aluminum from bauxite. U. B. Voisin. No. 140,404. Jan. 28, 1929; in France Feb. 15, 1928.

Process for pickling metals. V. Bertleff. No. 140,437. July 7, 1928; in Austria July 9, 1927 and Feb. 13, and June 9, 1928.

Process for increasing the corrosion-resistance of shaped objects of magnesium alloys. I. G. Farbenindustrie A.-G. No. 140,438. Jan. 8, 1929; in Germany Feb. 2, 1928.

Iron alloy and process for making it. British & Dominions Feralloy, Ltd. No. 140,470. Aug. 9, 1928; in Great Britain Sept. 3, 1928.

Partition for separating the electrolytic products in the fusion electrolysis of chlorides, particularly that of magnesium. I. G. Farbenindustrie A.-G. No. 140,471. Nov. 16, 1928; in Germany Dec. 23, 1927.

Automatic release for the clutch for the pulling drums of wire-drawing machines. C. Rasch. No. 140,472. Sept. 13, 1929.

Device for rotating gears in quenching tanks during hardening. F. Klopp. No. 140,473. Sept. 12, 1929.

Process for making the hard lead parts of storage battery electrodes. I. G. Farbenindustrie A.-G. No. 140,503. Apr. 4, 1929; in Germany May 12, 1928 and Feb. 4, and Feb. 5, 1929.

Individual electric drive for rolls. F. Tacke. No. 140,508. June 3, 1929. in Germany Jan. 3, 1929.

Process and apparatus for the reduction of metalliferous materials and for the production of metals and alloys. W. A. Loke. No. 140,780. Dec. 26, 1928.

Process for making improvable aluminum alloys. O. Reuleaux. No. 140,781. Mar. 20, 1929; in Germany Apr. 13, 1928.

Process for sand casting light metals, particularly magnesium and its alloys. I. G. Farbenindustrie A.-G. No. 140,782. Aug. 1, 1929; in Germany Sept. 19, 1928.

Process for bright-annealing metallic objects. A.-G. Brown, Boveri & Cie No. 140,789. May 1, 1929.

Process for heat treating non-cementable metals and alloys. G. Schoenberg. No. 140,790. May 2, 1929; in Czechoslovakia May 19, 1928.

Process for making refractory products. Metallges. A.-G. No. 140,948 Aug. 20, 1927.

Process for eliminating the iron contained in bauxite and other aluminiferous minerals. U. B. Voisin. No. 141,013. Feb. 13, 1929; in France Feb. 15, 1928.

Process for soldering aluminum. A. Ulrich. No. 141,102. Mar. 5, 1930.

Electric soldering device. Elektrische Löt- und Schweiss Ges. m.b.H. No. 141,103. Sept. 9, 1929; in Germany Mar. 19, 1929.

Apparatus for soldering the seams of tin cans and the like by means of a soldering iron connected to the secondary of a transformer. Same patentee. No. 141,104. Sept. 19, 1929.

Charging device for bright-annealing furnaces. Siemens-Schuckertwerke A.-G. No. 141,106. July 22, 1929; in Germany Nov. 24, 1928.

Electric electrode furnace. P. L. J. Miguet and M. P. Perron. No. 141,165. May 21, 1929; in France June 7, 1928.

Process for precipitating at least one of the metals of the platinum group of the periodic system. N. V. Philips' Gloeilampenfabrieken. No. 141,562. May 26, 1928; in the Netherlands Oct. 20, 1927.

Antifriction alloy. H. Kanz. No. 141,610. Feb. 1, 1929.

Process for making tools out of homogeneous alloys of great hardness. F. Krupp A.-G. No. 141,611. July 24, 1929.

Mechanical process for improving the properties of metals and alloys, particularly cast iron. Cie. des Fontes Girées (S. A.). No. 141,612. July 31, 1929.

Means for testing the welds of rectifier tanks. A.-G. Brown, Boveri & Cie. No. 141,679. Oct. 7, 1929; in Germany Oct. 17, 1928.

Prolonging Life of Gyratory Crusher Mantles

Recent tests by a mining company in Northern California have shown the application of Hascrome welding rod to worn crusher mantles. The average life of a manganese steel mantle crushing copper pyrites was found to be approximately 6 months. At the end of this time the $2^{1}/_{2}$-in. thick metal is practically worn through. One of these castings was reclaimed after being taken out of service by building up the worn surface with Hascrome. Ninety pounds of this material was used, requiring 25 hr. of labor to apply it. The total cost of rebuilding, including overhead, amounted to slightly more than 25% of the cost of a new mantle. At the end of four months, this part, having crushed 28,000 tons of copper pyrites, showed but $^{5}/_{32}$ in. of wear. It was again recoated and put back into service.

Manufacturers' Literature Reviews

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment should be of interest to the readers of METALS & ALLOYS. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* METALS & ALLOYS *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department.*—EDITOR.

1210 **Udylite News.**—The May issue of the Udylite News features article "Udylite in the Bicycle Industry." Udylite Process Co., 3220 Bellevue Ave., Detroit, Mich.

1211 **Industrial Heating Devices.**—Leaflet GEC-81A illustrates the various industrial heating devices manufactured by the General Electric Company, Schenectady, N. Y.

1212 **Mikrotast Gages.**—6-page bulletin gives data on fixed internal gages, adjustable internal gages with centering support, electro-mechanical mikrotast for fine wire and saddle gages. Coats Machine Tool Co., Inc., 110 West 40 St., New York, N. Y.

1213 **Drawing Furnace for Steel.**—Leaflet GEA-785B describes the GE Air Drawing-Oven Type AD for drawing carbon steel at temperatures up to 750° F. General Electric Company, Schenectady, N. Y.

1214 **Atomic-Hydrogen Arc-Welding Equipment.**—Leaflet GEA-823C describes the process of welding with hydrogen by the continuous independent arc. The equipment covered in this leaflet is for hand welding on 50 and 60 cycle circuits only. General Electric Company, Schenectady, N. Y.

1215 **Industrial Haulage Locomotives.**—Gas-Electric Type-30 Ton is covered in circular GEA-1230A. Trolley with Storage Battery Type-85 Ton is covered by circular GEA-1286. Trolley Type-85 Ton by circular GEA-1287. General Electric Company, Schenectady, N. Y.

1216 **Centrifugal Compressors.**—Bulletin GEA-1280 illustrates GE centrifugal air compressors. Applications listed. 12 pages. General Electric Company, Schenectady, N. Y.

1217 **Selsyn Motors for Remote Signaling, Control and Indication.**—Bulletin GEA-722B lists a number of applications of Selsyn motors. The bulletin illustrates the operation of the Selsyn. General Electric Company, Schenectady, N. Y.

1218 **Flexible Couplings and Speed Reducers.**—Circular 1887 contains complete descriptions, capacities, dimensions and weights of the different types of flexible couplings. Illustrations include typical applications of each type. Circular 1891 contains full information about the application, construction, ratings and dimensions of vertical type speed reducers for single and double reductions and right-angle drives. Numerous existing applications of the different types are illustrated. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

1219 **Wound Rotor Induction Motors.**—4-page leaflet describes the application and construction of type CW wound rotor induction motors. These motors have a wide application range for driving pumps and compressors and for other constant and varying speed continuous duty services. Leaflet 20490. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

1220 **Acid Proof Drainage Pipe and Fittings.**—Direct mail piece describes the installation of "Fahralloy" acid-proof drainage pipe and fittings in the Daily News and Herald-Tribune buildings in New York. Illustrations are also shown. Southern Manganese Division, American Manganese Steel Company, 66 Ridge Ave., St. Louis, Mo.

1221 **Flow Meters.**—These are direct mail pieces, one giving the different types of meters for all pressures up to 5000 pounds. The other is entitled "The 1930 Republic Flow Meter" and gives the list of men responsible for the design of the Republic Flow Meter. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill.

1222 **Brown Instruments.**—This is a 24-leaf circular giving 24 cost cutters by using Brown Instruments. Brown Instrument Company, 4482 Wayne Ave., Philadelphia, Pa.

1223 **Graphic Instruments.**—Bulletin 727 shows how Esterline-Angus Graphic Instruments are used to record the test data on electric motors as they pass by the testing plant on a conveyor. Instead of using indicating instruments, pencils and log books, in the hands of human observers, the electrical data are automatically recorded by six Esterline-Angus graphic instruments. Three minutes are required for four complete tests of each motor. Esterline-Angus Co., Indianapolis, Ind.

1224 **Instrument Investment News.**—Vol. III, No. 6, September 1930 issue of this circular is devoted to the Dissemination of Practical Information on the Measurement and Control of Manufacturing Operations. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

1225 **Laboratory & Power Plant Equipment.**—Bulletin No. 15, September 1930 describes and illustrates the various scientific laboratory and power plant equipment. The Refinery Supply Company, Tulsa, Oklahoma.

1226 **Polishing Machine.**—This circular describes the Automatic Polishing Machine which was designed in the laboratory of the Bureau of Standards after careful, accurate analyses of existing operating methods and equipment. It automatically produces a plane surface with a high quality polish. The Chemical Rubber Company, West 112th St., Cleveland, Ohio.

1227 **Dial Gage.**—A circular describing and illustrating the dial thickness gage, model 390. It is a light convenient thickness gage used for measuring all kinds of flat material, such as felt, sheet metal, leather, etc. Federal Products Corp., Providence, R. I.

1228 **Economy in Industry.**—Bulletin G-10 is issued for the information of all who may be directly or indirectly interested in knowing how modern industry is saving thousands of dollars in time, labor and material through the centralized control of all units of production. It describes and illustrates different instruments and their particular use in various buildings and plants. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill.

1229 **Mueller Bridge.**—Catalog No. 80-Z describes and illustrates the Mueller Bridge which is a high precision electrical instrument for checking the accuracy of thermometers and other various high-precision measurements of temperature that must be made from time to time in operating a power plant. Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa.

1230 **List Prices.**—This September 1930 leaflet gives the list prices to be used with Bristol's Catalog No. 4000. The Bristol Co., Waterbury, Conn.

1231 **Temperature.**—An 8-leaf circular entitled, "Chromium Plating Temperature." Temperature is a critical factor in chromium plating. To enable the plater to hold the temperature within the close limits essential for first quality work it is necessary to use an accurate thermometer. Foxboro Chromium Plating Thermometer has been made especially for this work. Foxboro Co., Foxboro, Mass.

1232 **Nickel.**—A 7-page leaflet entitled, "The Kocour Nickel Comparator." The Kocour Nickel Comparator is a practical method by which the nickel in solution is accurately, simply and directly measured. Price and description of this Nickel Comparator are given in the leaflet. This company also issued other leaflets entitled, "The La Motte H-Ion Comparator Set," "Standard Solutions," "Sulphates" and "Chlorides." Kocour Company, 4724 S. Turner Ave., Chicago, Ill.

1233 **Chromic Acid.**—This Kocour Chromic Acid Analytical Set is described and illustrated in a small pocket leaflet. It was developed to replace the hydrometer because of the latter's inaccuracy. Kocour Company, 4724 S. Turner Ave., Chicago, Ill.

1234 **Control Pyrometer.**—Catalog No. 202, loose leaf, 38 pages contains the latest data on Republic Control Pyrometers, Valves and Valve Controllers. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill.

1235 **Resistance Wire.**—10 pages with tables, curves and descriptions of various electrical alloys, also a bulletin on Allegheny Ohmaloy. Gilby Wire Company, 150 Riverside Avenue, Newark, New Jersey.

1236 **Pyrometers.**—A new catalog featuring Brown Indicating, Recording and Automatic Control Pyrometers. This catalogue contains 104 pages with 141 illustrations, many of which are in two colors. A résumé of the theory and practice of applied pyrometry is presented, together with descriptions and illustrations of all instruments, thermocouples, protecting tubes and other required equipment. Brown Instrument Company, 4482 Wayne Ave., Philadelphia, Pa.

1237 **Dividing Machines.**—Catalog No. 508 of the Société Genevoise d'Instruments de Physique of Geneva, Switzerland. It contains something of the history of their construction of linear and circular dividing machines. This new catalogue covers the redesign of all of their dividing machines in the last few years and represents the latest features incorporated in these linear and circular dividing machines. R. Y. Ferner Co., Investment Building, Washington, D. C.

1238 **Tube Furnace.**—Bulletin 1014 illustrates the Model U Furnace for temperatures between 700 and 1400° C. This furnace is designed for combustion analysis and similar work. The Sentry Company, Taunton, Mass.

1239 **Humidity Recorder.**—A reprint from the Journal of the Optical Society of America and Review of Scientific Instruments, June 1926, pages 623 to 652. Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.

1240 **Air Operated Controller.**—Catalogue 4000 illustrates and describes completely the operation and application of Bristol Air Operated Controller Equipment. 20 pages. Bristol Co., Waterbury, Conn.

1241 **Silent and Roller Chain.** A new 124-page catalogue giving complete data on silent and roller chain, also engineering data of practical value to chain users in figuring chain drives. It also gives complete information and engineering data on sprockets used in conjunction with silent and roller chain drives and on chain attachments for special purposes. Union Chain & Mfg. Co., Sandusky, Ohio.

1242 **Furnaces.**—A circular naming the plants that temper by the Homo Method and harden by the Hump Method. Also lists the plants using Homo nitriding furnaces. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

1243 **Micrometers.**—A booklet entitled "Precision Measuring Tools" describes and illustrates the various micrometers manufactured by the Swedish Gage Company, Detroit, Mich.

Metals & Alloys, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature the number of which I list below.

Name .... Position ....

Firm .... City ....

Street & No. .... State ....

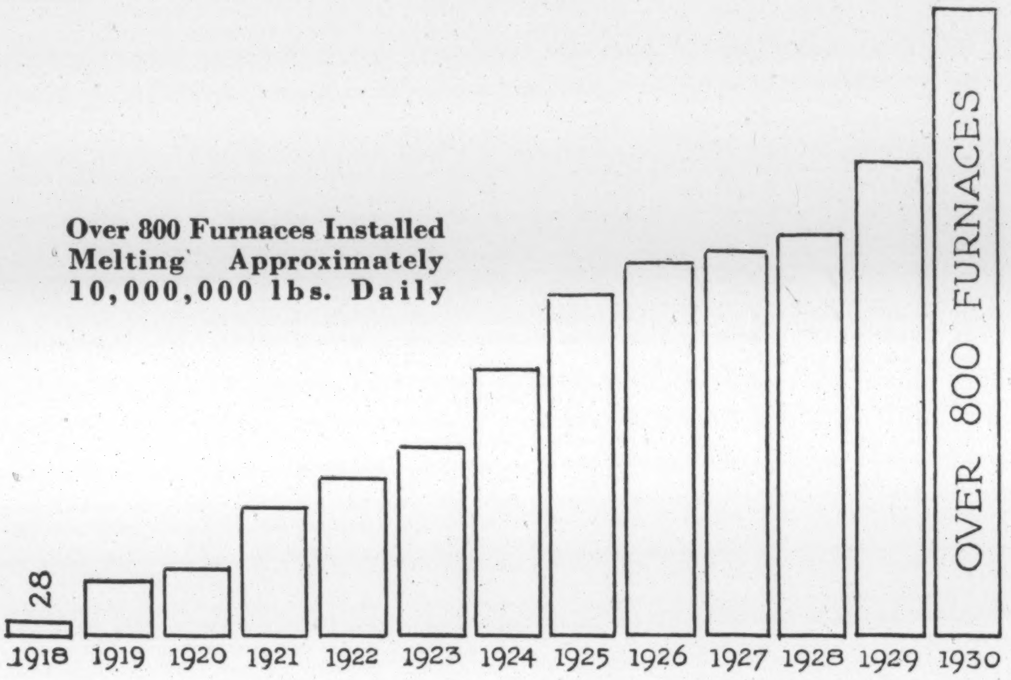
AJAX

AJAX

1880 1930

Ajax Golden Anniversary

Over 800 Furnaces Installed
Melting Approximately
10,000,000 lbs. Daily



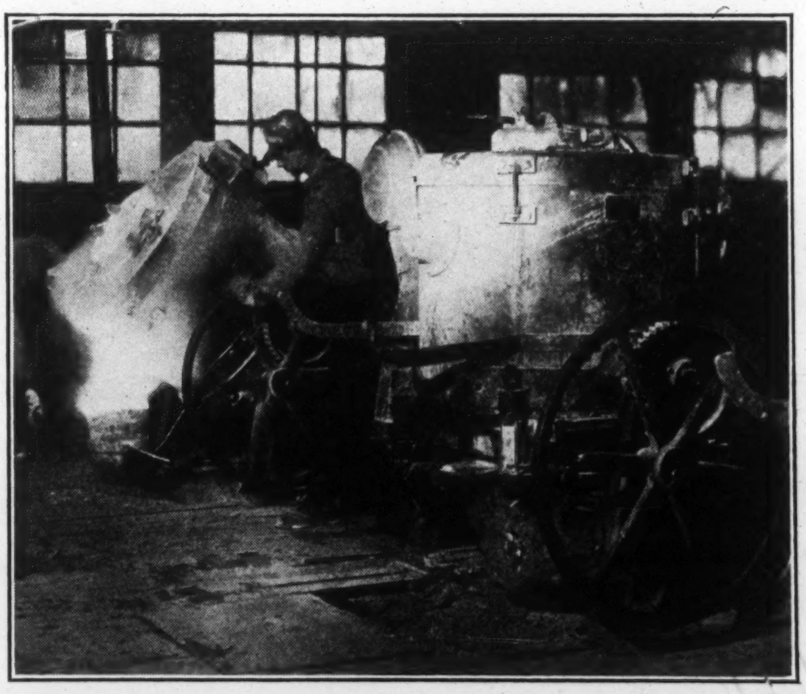
TRADE MARK

AJAX WYATT

ELECTRIC MELTING
FURNACES

FOR BRASS, BRONZE, NICKEL-SILVER, ZINC, ETC.

WRITE FOR OUR NEW
CATALOG. No. 22 JUST
OFF THE PRESS



A typical foundry installation used on red brass valve alloys

THE AJAX METAL COMPANY

Electric Furnace Division

Frankford Ave. bel. Girard Ave.

PHILADELPHIA

AJAX

AJAX

Library Tools for Uncovering Opportunities for Profit

The Condensed Chemical Dictionary ◆ ◆ ◆

Compiled and Edited by the Editorial Staff of The Chemical Engineering Catalog.

Second Edition Revised and Enlarged 1930

The New Dictionary contains 5000 new items not listed in the 1919 Edition.

551 Pages—*with Thumb Index*

Board Library Buckram $10.00
Flexible Keratol . . . $12.00

The Dictionary places at your disposal in a simplified and readily accessible form, a library of essential technical and commercial data on organic and inorganic chemicals, the medicinals, metals and alloys, minerals, fertilizers, explosives, pigments, oils and raw materials in general use.

Arranged in a straight alphabetical classification, it gives the following facts about 12,000 chemicals (including cross references):

Names of Chemicals and Substances
Uses
Chemical Formulas
Colors
Properties
Constants
Specific Gravities
Melting Points
Boiling Points
Solubility
Materials from which they are made
Grades
Method of Manufacture
Method of Purification
Shipping Containers and their sizes
Fire Hazards
Railroad Shipping Regulations

◆

Sheet Steel and Tin Plate
R. W. SHANNON
285 Pages Illustrated Price $5.00

A PRACTICAL work on the utilization of sheet steel and tin plate in the steel-fabricating arts. The essential facts concerning sheet steel and tin plate are clearly set forth in every-day language, enabling the layman to gain therefrom an insight into the possibilities and limitations of these important kinds of steel products, which will permit him to understand present day uses better, and possibly to visualize new uses, for these materials.

Tin
C. L. MANTELL
353 Pages Illustrated Price $7.00

A COMPREHENSIVE survey of the various phases of the production of tin from its ores to its commercial application. The history, physical and chemical properties, and the production, distribution, and consumption of the metal have been presented and discussed from the viewpoint of the chemist, the metallurgist, and the chemical engineer rather than from the viewpoint of the mining engineer or the mechanical engineer. Secondary tin and detinning of tin-plate scrap has been treated from the economic as well as from the metallurgical and chemical viewpoint.

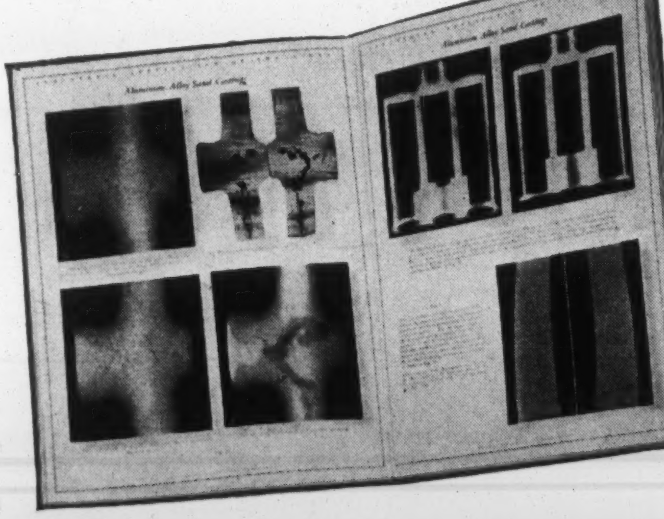
Protective Metallic Coatings
HENRY S. RAWDON
277 Pages Illustrated Price $5.50

AN up-to-date survey of the field of corrosion prevention, or retardation, particularly from iron and steel, especially useful to the engineer, manufacturer, metallurgist and chemist. The various coating methods—hot-dipping, cementation, metal spraying, electroplating, alloying, chemical treatment, etc.—are described in detail, as are the coatings produced by these methods using zinc, tin, copper, nickel, chromium and other metals. Methods of testing such coatings are given and an extensive bibliography is appended.

419 Fourth Ave., The Chemical Catalog Co., Inc., New York, U. S. A.

Which Use of the X-Ray might interest you—

FOR TESTING CASTINGS
" " MOLDS
" " WELDINGS
" " ASSEMBLIES ?



ALL are described in this new booklet. Numerous illustrations show how the x-ray is getting results for many different kinds of industries. We'll gladly send a complimentary copy if you'll write us. Our research department is ready to collaborate in determining whether the x-ray can aid you. Have you a problem regarding which you would like information?

Industrial Application
X-RAY

SEND COUPON FOR BOOKLET

GENERAL ELECTRIC X-RAY CORPORATION
2012 Jackson Boulevard Chicago, Ill., U. S. A.
FORMERLY VICTOR X-RAY CORPORATION

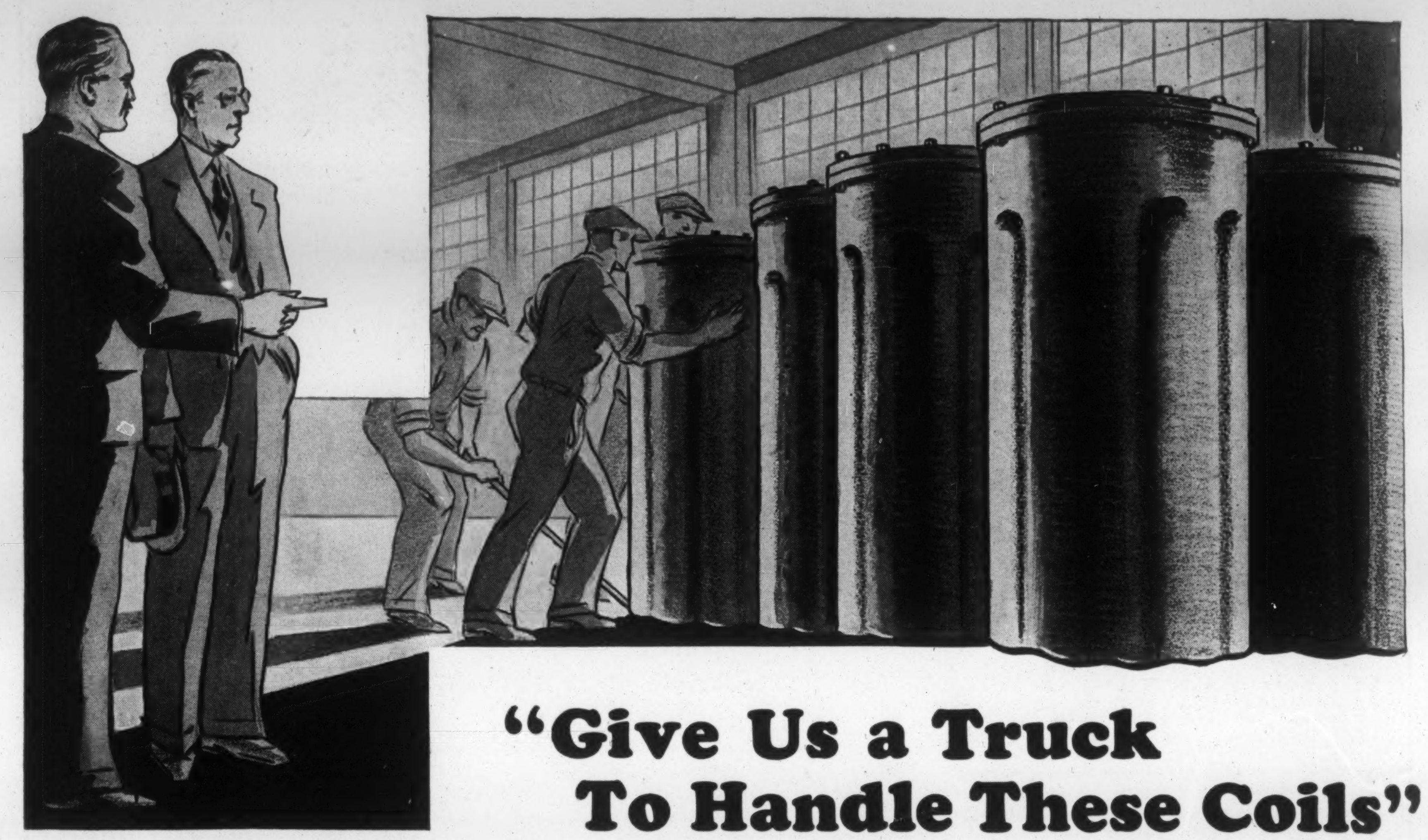
Join us in the General Electric program broadcast every Saturday evening over a nationwide N. B. C. network.

General Electric X-Ray Corporation, 2012 Jackson Blvd., Chicago 300
Send complimentary copy of "Industrial Application of the X-Ray."

Signed ....

Firm ....

Street .... City .... State ....



"Give Us a Truck To Handle These Coils"

ENGINEERS of the Wright-Hibbard Industrial Electric Truck Co., Inc., Phelps, N.Y., fulfilled the requirements of the loading coil manufacturer by developing a series of electric trucks, equipped with adjustable forks which lower to the floor and pick up the loading coils and such loads as low dollies and skids. The forks which carry the load are adjustable by means of a hand wheel within easy reach of the operator.

Subject to terrific strain when heavy loads are picked up, the forks, and the shafts on which the forks ride, must be strong and tough. They must also possess a degree of flexibility to compensate for strain and shock encountered when carrying heavy loads over rough floor surfaces.

After careful investigation and study of many analyses of steels, Wright-Hibbard engineers selected Vanadium Steel for the adjustable forks and their shafts. Vanadium Steel provided the requisite resiliency, toughness and strength—in parts of smaller section and lighter weight than would have been possible with other steels which were considered for these applications.

Many manufacturers have found wider adaptability for their products—others have eliminated parts failures and improved product dependability—with the proper analysis of Vanadium Steel in vital units. Our metallurgists welcome the opportunity to cooperate with manufacturers in the solution of steel problems. What is yours? Write us about it.

VANCORAM BRAND

FERRO-ALLOYS of vanadium, silicon, chromium and titanium; silico-manganese, tungsten and molybdenum, produced by the Vanadium Corporation of America, are used by steel makers in the production of high-quality steels.

VANADIUM CORPORATION OF AMERICA
120 BROADWAY, NEW YORK, N. Y.

CHICAGO
Straus Building

PITTSBURGH
Oliver Building

DETROIT
Book Tower

Plants at Bridgeville, Pa., and Niagara Falls, N. Y.
Research and Development Laboratories at Bridgeville, Pa.

VANADIUM STEELS

for strength, toughness and durability